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Amsterdam, The Netherlands

September 17-21, 1984

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United States of America National Committee
for Representation of the United States to
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Pollution Research and Control

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Donald F. Carey
Project Officer

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Under a grant from the U.S. Environmental Protection Agency (EPA), 32 members of the U.S. American National Committee (USANC) participated in the twelfth biennial International Conference on Water Pollution. The final two-volume report documenting this conference includes the basic themes of ground-water pollution and recharge, water quality problems, river and lake management, wastewater treatment and disposal, sludge treatment and disposal, stormwater and runoff management and control, treatment and reuse of industrial wastewater. The final report also analyzes pertinent remarks, comments, and ideas that emerged from discussions of the papers.

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CONTENTS

Page

LETTER OF TRANSMITTAL.............................. iii
KEY TO REVIEWS..................................... xi
EXECUTIVE SUMMARY.................................. xxxix

I. INTRODUCTION.................................... 1

II. CONFERENCE SESSION REPORTS..................... 5

Conference Presentations

Aerobic Films 5
Paper Nos. C-1, C-2, C-3, C-4, C-5
Reviewer: Francis A. DiGiano

Phosphorus Removal................................. 13
Paper Nos. C-6, C-7, C-8, C-9, C-10
Reviewer: Clifford W. Randall

Phosphorus Removal; Anaerobic Treatment;
Oxidation and Formation of Sulfide................. 23
Paper Nos. C-11, C-12, C-13, C-14, C-15
Reviewer: Joseph F. Malina, Jr.

Activated Sludge................................... 30
Paper Nos. C-16, C-17, C-18, C-19, C-20
Reviewer: Bruce E. Rittman

Kinetics and Aeration in Aerobic Treatment 36
Paper Nos. C-21, C-22, C-23, C-24, C-25
Reviewer: James E. Alleman

Industrial Wastewater Treatment;
Nitrification and Denitrification.................. 42
Paper Nos. C-26, C-27, C-28, C-29, C-30
Reviewer: James W. Patterson

Nitrification and Denitrification.................. 47
Paper Nos. C-31, C-32, C-33, C-34
Reviewer: C. P. Leslie Grady, Jr.

Page

Land Treatment of Waste and Wastewater.... 54
Paper Nos. C-35, C-36, C-37, C-38, C-39
Reviewer: Charles P. Gerba

Sludge.................................... 59
Paper Nos. C-40, C-41. C-42, C-43, C-44
Reviewer: Charles R. O'Melia

Sludge.................................... 67
Paper Nos. C-45, C-46, C-47, C-48, C-49
Reviewer: Paul T. Bowen

Disinfection; Modeling; Virology.......... 72
Paper Nos. C-50, C-51, C-52, C-53, C-54
Reviewer: Judith B. Carberry

Virology and Particles in Surface Waters.. 81
Paper Nos. C-55, C-56, C-57, C-58, C-59
Reviewer: W. Wesley Eckenfelder, Jr.

Cementation............................... 86
Paper No. C-60
Reviewer: Edwin E. Herricks

Eutrophication............................ 88
Paper Nos. C-61, C-62, C-63, C-64
Reviewer: Edwin E. Herricks

Production of Plants and Algae from Wastewater................................ 94
Paper Nos. C-65, C-66, C-67, C-68
Reviewer: Alan H. Molof

Analysis of Water and Wastewater and Biological Water Quality Assessment....... 106
Paper Nos. C-69, C-70, C-71, C-72, C-73
Reviewer: Lawrence H. Keith

Resuspension and Sedimentation and Benthal Deposits.......................... 114
Paper Nos. C-74, C-75, C-76, C-77, C-78
Reviewer: Curtis W. Bryant, Jr.

Page

Modeling Water Quality.................... 118
Paper Nos. C-79, C-80, C-81
Reviewer: David W. Hendricks

Dispersion in Estuaries................... 124
Paper Nos. C-82, C-83
Reviewer: David W. Hendricks

Physical-Chemical Treatment............... 128
Paper Nos. C-84, C-85, C-86, C-87, C-88
Reviewer: Walter J. Weber, Jr.

Physical-Chemical Treatment............... 134
Paper Nos. C-89, C-90, C-91, C-92, C-93
Reviewer: John R. Schultz

Effects of Agriculture on Water Quality... 140
Paper Nos. C-94, C-95, C-96
Reviewer: E. Robert Baumann

Urban Runoff.............................. 147
Paper Nos. C-97, C-98
Reviewer: E. Robert Baumann

Marine Wastewater Disposal and Standards; Transport and Processes in Sewers......... 151
Paper Nos. C-99, C-100, C-101, C-102
Reviewer: Boris M. Khudenko

Implementation of Research Needs.......... 157
Reviewer: E. H. Bryan

Poster Presentations

Anaerobic Treatment; Water Quality Modeling; Wastewater Treatment in Fluidized Bed............................. 160
Poster Nos. P-8, P-15, P-29
Reviewer: Joseph F. Malina, Jr.

New Approaches to Sludge Disposal, Sludge Separation and Algal Production Potential................................ 164
Poster Nos. P-7, P-11, P-14,
Reviewer: Judith B. Carberry

Page

Control of Wastewaters and Treatment Works.................................... 167
Poster Nos. P-4, P-10, P-20
Reviewer: Herbert C. Preul

Wastewater and Sludge Treatment Processes.................................... 172
Poster Nos. P-49, P-5, P-44, P-35, P-38
Reviewer: C. P. Huang

Water Treatment............................ 179
Poster Nos. P-25
Reviewer: Charles P. Gerba

Modular Water Treatment of Hazardous Wastes and Prediction of Lake Water Quality................................... 180
Poster Nos. P-3, P-12, P-17
Reviewer: Francis A. DiGiano

Acidified Waters.......................... 184
Poster No. P-39
Reviewer: Edwin E. Herricks

Water Quality and Heavy Metal Chemistry... 186
Poster Nos. P-16, P-48, P-55, P-57, P-42
Reviewer: C. P. Huang

Toxicants in Water........................ 192
Poster Nos. P-33
Reviewer: Bruce E. Rittman

Water Quality Modeling.................... 194
Poster No. P-18
Reviewer: Edwin E. Herricks

Water Quality Modeling 196
Poster Nos. P-2, P-22
Reviewer: David W. Hendricks

General................................... 198
Poster Nos. P-9, P-40
Reviewer: Curtis W. Bryant, Jr.

General................................... 200
Poster Nos. P-27, P-34, P-37
Reviewer: Paul T. Bowen

Page

III. PRE-CONFERENCE AND POST-CONFERENCE SESSION REPORTS.......................... 203

Seminar on Freshwater Biological Monitoring................................ 203
Paper Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21
Reviewer: Edwin E. Herricks

Water Virology Seminar..................... 217
Paper Nos. C-57, 1, 3, 4, 5, V-5, V-8, V-14, C-54, 10, 11, V-1, V-6, V-11, C-56, 12, 2, 13, V-4, V-9, V-13, V-17, C-53, C-55, 7, 8, 9, 14, V-15, V-16
Reviewer: Mark D. Sobsey

Seminar on Advanced Treatment Technologies for Removal and Disposal of Micropollutants........................... 242
Paper Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Reviewers: Paul H. King and Raymond A. Sierka

IV. OVERVIEW OF PERTINENT CONFERENCE DEVELOPMENTS............................. 251

A. Developments at Formal Sessions...... 251

Aerobic Films........................ 251
Activated Sludge..................... 252
Biological Nitrification; Denitrification.................... 253
Biological Phosphorus Removal........ 254
Chemical Phosphorus Removal.......... 254
Physical-Chemical Treatment.......... 255
Disinfection and Virology............ 258
Land Treatment of Waste and Wastewater......................... 260
Sludge Treatment and Disposal........ 261
Anaerobic Treatment.................. 262
Use of Mathematical Models........... 262
Eutrophication....................... 263
Hyacinth Treatment, Algal Harvesting, and Duckweed Treatment............. 264
Resuspension and Sedimentation of Particulates...................... 264

Page

Benthal Deposits..................... 265
Analysis of Water and Wastewater..... 265
Transport and Processes in Sewers.... 266
Biomonitoring.. 266

B. Developments Outside of Formal Sessions........................... 268

Biological Nitrogen Removal.......... 268
Biological Phosphorus Removal........ 268
Anaerobic Treatment.................. 270
Rotating Biological Contactors....... 271
Physical-Chemical Treatment.......... 272
Virology............................. 273
Hazard Evaluation for Biological Effects........................... 277
Modeling of Environmental Systems.... 278
Cost and Energy Effectiveness for Wastewater Treatment............... 279
Pollution Control Research Topics.... 279
Pollution Control in Eastern Europe.. 280
Industrial Trade Exhibits--Amsterdam. 282
European Institutions--Water Pollution Control.................. 282
Impact of Toxic Industrial Pollutants on Water Quality........ 284
Training of Operating Personnel...... 284

APPENDICES............................... 285

A. Program: 12th Biennial International Conference on Water Pollution Control September 17-21, 1984................ 286

B. Program: Seminar on Freshwater Biological Monitoring, September 12-15, 1984, Cardiff, United Kingdom........ 318

Program: Seminar on Advanced Treatment Technologies for Removal and Disposal of Micropollutants, September 24-25, 1984, Antwerp, Belgium.............................. 325

C. Memorandum: "Development of Report for E.P.A. on IAWPRC Amsterdam Conference," August 1, 1984.......... 330

Page

Memorandum: "Assignments for Development of USANC Report on Amsterdam Conference," August 28, 1984 335

Memorandum: "Supplement to Guidelines for Preparation of Individual Reports," October 23, 1984 346

D. *Assignments*: Participants in USANC Report 354

KEY TO REVIEWS

Number — Title and Authors — Page

12TH INTERNATIONAL CONFERENCE ON WATER POLLUTION RESEARCH

Paper Presentations

C-1. Removal of Soluble Substrates in Fixed Films 5
J. la Cour Jansen, P. Harremoes (Denmark)

C-2. Influence of Particulate Organics on the Removal of Dissolved Organics in Fixed-Film Biological Reactors 6
E. Sarner, S. Marklund (Sweden)

C-3. Competition in Biofilms 7
O. Wanner, W. Gujer (Switzerland)

C-4. The Effect of Load Fluctuations on the Effluent Concentration Produced by Fixed-Film Reactors 8
B. E. Rittman (U.S.A.)

C-5. Evaluation of Temperature Effects on Trickling Filter Plant Performance 10
A. Adin, E. R. Baumann, F. D. Warner (U.S.A., Israel)

C-6. The Role of an Anaerobic Stage on Biological Phosphorus Removal 13
T. Fukase, M. Shibata, Y. Miyaji (Japan)

C-7. The Influence of Extended Anaerobic Retention Time on the Performance of Phoredox Nutrient Removal Plants 15
A. Gerber, C. T. Winter (South Africa)

C-8. Location of Phosphorus in Activated Sludge and Function of Intracellular Polyphosphates in Biological Phosphorus Removal Process 16
T. Mino, T. Kawakami, T. Matsuo (Japan)

Number	Title and Authors	Page
C-9.	Modeling Phosphate Sludge Production.. R. G. Veldkamp (The Netherlands)	17
C-10.	Phosphate Removal from Wastewater by Crystallization Method............. I. Joko (Japan)	18
C-11.	Phosphate Removal by Crystallization in a Fluidized Bed.................... J. C. van Dijk, H. Braakensiek (The Netherlands)	23
C-12.	Batch Anaerobic Methanogenesis of Phenolic Coal Conversion Wastewater... P. M. Fedorak, S. E. Hrudey (Canada)	24
C-13.	Thermophilic Anaerobic Contact Digestion of Palm Oil Mill Effluent... A. Ibrahim, B. G. Yeoh, S. C. Cheah, A. N. Ma, S. Ahmed, T. Y. Chew, R. Raj, M. J. A. Wahid (Malaysia)	25
C-14.	Oxidation of Sulfide and Thiosulfate and Storage of Sulfur Granules in Thiothrix from Activated Sludge....... P. H. Nielsen (Denmark)	26
C-15.	Kinetic Studies of the Microbiological Conversion of Sulphate to Hydrogen Sulphide and Their Relevance to Sulphide Generation within Sewers..... G. A. Holder, G. Vaughan, W. Drew (Australia)	27
C-16.	Mixing and Detention Time Distribution in Activated Sludge Tanks............. H. Bode, F. Seyfried (Federal Republic of Germany)	30
C-17.	Influence of Macromixing on Organic Carbon Uptake and Solids Production by Aerobic Suspended Biomass.......... S. Elmaleh, T. I. Yoon, A. Grasmick (France)	31

Number	Title and Authors	Page
C-18.	An Equalization Control Strategy for Activated Sludge Process Control...... P. L. Dold, H. O. Buhr, G. v. R. Marais (South Africa)	32
C-19.	The A-B Process: A Novel Two Stage Wastewater Treatment System........... A. I. Versprille, B. Zuurveen, Th. Stein (The Netherlands)	32
C-20.	Flexible Modelling of the Activated Sludge System--Theoretical and Practical Aspects..................... M. S. Sheffer, M. Hiraoka, K. Tsumura (Israel, Japan)	33
C-21.	Determination of Kinetic Constants of Activated Sludge Microorganisms....... J. S. Cech, J. Chudoba, P. Grau (Czechoslovakia)	36
C-22.	The Potential Use of Enzymes for Removal of Aromatic Compounds from Water................................. S. W. Maloney, J. Manem, J. Mallevialle, F. Fiessinger (France)	37
C-23.	Development of Pollutant Specific Models for Toxic Organic Compounds in the Activated Sludge Process....... A. T. Watkin, W. W. Eckenfelder, Jr. (U.S.A.)	38
C-24.	The Kinetic Analysis of BOD and Nitrogen Removal in an Oxidation Ditch.............................. Y. Terashima, M. Ishikawa (Japan)	39
C-25.	Steady State Measurement of Oxygenation Capacity.................. K. de Korte, P. Smits (The Netherlands)	39
C-26.	Removal of Iron Cyanide from Gold Mill Effluents by Ion Exchange........ D. T. Vachon (Canada)	42

Number	Title and Authors	Page
C-27.	Total Effluent Treatment and Rinse Water Reclamation in a Semiconductor Device Manufacturing Facility......... P. S. Cartwright (U.S.A.)	43
C-28.	Development of a New Process for Treating Uranium Mining Effluents..... P. M. Huck, W. B. Anderson, R. C. Andrews (Canada)	44
C-29.	Dynamics of Nitrification in a Biological Fluidized Bed Reactor...... S. W. Hermanowicz, J. J. Ganczarczyk (U.S.A., Canada)	44
C-30.	Modeling, Optimization and Design of Fluidized Beds for Biological Denitrification....................... Th. J. Nieuwstad (The Netherlands)	45
C-31.	Mathematical Model of Simultaneous Organic Oxidation, Nitrification, and Denitrification in Rotating Biological Contactors................. Y. Watanabe, S. Masuda, K. Nishidome, C. Wantawin (Japan, Thailand)	47
C-32.	The Application of Predenitrification Nitrification Technology for Trace Contaminant Control................... H. Melcer, S. G. Nutt (Canada)	49
C-33.	Elevated Nitrite Occurrence in Biological Wastewater Treatment Systems............................... J. E. Alleman (U.S.A.)	50
C-34.	Single Sludge Anoxic-Aerobic Systems for Biological Treatment of Coke Plant Wastewaters..................... M. Beccari, A. C. DiPinto, R. Passino, R. Ramadori, V. Tandoi (Italy)	51

Number	Title and Authors	Page
C-35.	Epidemiological Evidence for Helminth and Cholera Transmission by Vegetables Irrigated with Wastewater--A Case Study H. I. Shuval, P. Yekutiel, B. Fattal (Israel)	54
C-36.	Wastewater Treatment by Artificial Wetlands R. M. Gersberg, B. V. Elkins, C. R. Goldman (U.S.A.)	55
C-37.	Use of Peracetic Acid in Operational Sewage Sludge Disposal to Pasture J. A. L. Fraser, A. F. Godfree, F. Jones (United Kingdom)	56
C-38.	Considerations on Water, Oil and Air in Porous Media H. O. Schiegg (Switzerland)	57
C-39.	Leachate Attenuation in the Unsaturated Zone Beneath Landfills: Instrumentation and Monitoring of a Site in Southern England H. D. Robinson, J. L. Lucas (United Kingdom)	57
C-40.	Settling of Nutrient Removal Activated Sludges A. R. Pitman (South Africa)	59
C-41.	Sludge Conditioning: Effects of Sludge Biochemical Composition P. T. Bowen, T. M. Keinath (U.S.A.)	61
C-42.	Floc-Forming Substances Extracted from Activated Sludge with Ammonium Hydroxide and EDTA Solutions T. Sato, Y. Ose (Japan)	62
C-43.	Highly Efficient Anaerobic Digestion with Thermal Pretreatment M. Hiraoka, N. Takeda, S. Sakai, A. Yasuda (Japan)	63

Number	Title and Authors	Page
C-44.	Production of Liquid Alum from Aluminum-Anodizing Sludges............ F. M. Saunders, C. B. Harmon (U.S.A.)	64
C-45.	Sludge Treatment Technology and Ionizing Radiation.................... M. Sedlacek, M. Koubik, K. Vacek, J. Rejholec (Czechoslovakia)	67
C-46.	Sludge Stabilisation and Disinfection by Means of Autothermal Aerobic Digestion with Oxygen.................. B. C. Trim, J. E. McGlashan (South Africa)	68
C-47.	Decontaminating Biological Sludge for Agricultural Use...................... L. Wong, J. G. Henry (Canada)	69
C-48.	Fractionation of Heavy Metals in Sewage Sludges........................ R. J. Oake, C. S. Booker, R. D. Davis (United Kingdom)	69
C-49.	Controlling Metal Uptake from Heat-Treated Sludge Applied to Grasslands.. J. W. Vail, D. G. Devey (South Africa)	70
C-50.	Disinfection of Drinking Water Rich in Bromide with Chlorine and Chlorine Dioxide, While Minimizing the Formation of Undesirable By-Products.. Ch. Rav-Acha, A. Serri, E. (Goldstein) Choshen, B. Limoni (Israel)	72
C-51.	Sunlight Photo-Oxidation of Organic Pollutants in Wastewater.............. A. J. Acher (Israel)	73
C-52.	Synthesis Modelling of Municipal Wastewater Treatment Systems.......... A. S. Camara, C. W. Randall, L. C. Fair (Portugal, U.S.A.)	74

Number	Title and Authors	Page
C-53.	F Specific RNA Bacteriophages in Sewage: Methodology and Occurrence.... A. H. Havelaar, W. M. Hogeboom, R. Pot (The Netherlands)	75
C-54.	Inactivation of Hepatitis A Virus, Other Enteric Viruses and Indicator Organisms in Water by Chlorination.... W. O. K. Grabow, P. Coubrough, C. Hilner, B. W. Bateman (South Africa)	77
C-55.	Effects of Water Quality on Microporous Filter Methods for Ente[illegible]c Virus Concentration........... M. D. Sobsey, T. Cromeans, A. R. Hickey, J. S. Glass (U.S.A.)	81
C-56.	Factors Controlling the Survival of Viruses in Groundwater................ M. V. Yates, C. P. Gerba (U.S.A.)	82
C-57.	Occurrence of Viruses in Treated Drinking Water in the United States... E. W. Akin (U.S.A.)	82
C-58.	Colloidal Stability of Particles in Lakes: Measurement and Significance.. W. Ali, C. R. O'Melia, J. K. Edzwald (U.S.A.)	83
C-59.	Sorption of Ammonia Nitrogen on River Borne Suspended Solids.......... R. F. Wukasch, L. P. Moos (U.S.A.)	84
C-60.	Mechanism and Kinetics of Cementation Processes............................. B. Khudenko (U.S.A.)	86
C-61.	Phosphorus, Nitrogen & Chlorophyll-A Concentrations in a Typical Dutch Polder Lake Tjeukemmer, In Relation to its Water Regime Between 1968 and 1982................................... H. De Hann, J. R. Moed (The Netherlands)	88

Number	Title and Authors	Page
C-62.	The Role of Phytoplankton in the Dissolved Oxygen Budget of a Stratified Estuary.................... P. G. Soulsby, M. Mollowney, G. Marsh, D. Lowthion (United Kingdom)	89
C-63.	Restoration of Lake Veluwe, The Netherlands, by Reduction of Phosphorus Loading and Flushing....... S. H. Hosper (The Netherlands)	91
C-64.	Water Quality Control of the Andelse Maas Basin, The Netherlands, by Iron Dosing........................... A. C. Hoekstra, K. D. Maiwald (The Netherlands)	92
C-65.	Treatment of Agro-Industrial Wastes Using Water Hyacinth.................. C. K. John (Malaysia)	94
C-66.	The Selective Cultivation of Easily Harvestable Algae Using Crossflow-Microscreening........................ W. A. Pretorius, L. C. Hensman (South Africa)	96
C-67.	Waste Water Recycling by Duckweed for Protein Production and Effluent Renovation............................ G. Oron, L. R. Wildschut, D. Porath (Israel, The Netherlands)	99
C-68.	A Potential Treatment Alternative for Swine Wastewater in the Tropics....... P. Y. Yang, S. Y. Nagano (U.S.A.)	101
C-69.	The Application of Information about Conductivity in the Computing of Ion Concentrations, Illustrated by Certain Surface Waters Situated in Lower Saxony................................ W. Walther, M. Gorsler, J. Poltz, D. Bock (Federal Republic of Germany)	106

Number	Title and Authors	Page
C-70.	Hazardous Substances in Waste Water... A. B. van Luin, W. van Starkenburg (The Netherlands)	107
C-71.	Continuous, Automatic Detection of Organophosphates and Carbamates in Water Utilizing Enzyme Microcalorimetry....................... W. S. G. Morgan, P. C. Kuhn, P. P. van Niekerk (South Africa)	108
C-72.	Biological Assessment of Water Quality in Running Water Using Macroinvertebrates: A Case Study for Limburg, The Netherlands............... H. H. Tolkamp (The Netherlands)	110
C-73.	Aquatic Habitat Analysis as an Element of Water Resources Planning and Management......................... E. E. Herricks (U.S.A.)	111
C-74.	Erosional Process of Cohesive Sediments............................. T. Kusuda, T. Umita, K. Koga, T. Futawatari, Y. Awaya (Japan)	114
C-75.	Quantification of Wind Induced Resuspension in a Shallow Lake........ R. H. Aalderink, L. Lijklema, J. Breukelman, W. van Raaphorst, A. G. Brinkman (The Netherlands)	115
C-76.	The Behavior of Suspended Sediments and Muds in an Estuary................ T. Umita, T. Kusuda, Y. Awaya, M. Onuma, T. Futawatari (Japan)	115
C-77.	Stabilization of Organic Carbon and Nitrogen in Consolidating Benthal Deposits.............................. C. W. Bryant, Jr., L. G. Rich (U.S.A.)	116

Number	Title and Authors	Page
C-78.	The Calculation of Transport Coefficients of Phosphate and Calcium Fluxes Across the Sediment-Water Interface, from Experiments with Undisturbed Sediment Cores............ W. van Raaphorst, A. G. Brinkman (The Netherlands)	117
C-79.	Stream Modeling of Non-Conventional Water Quality Parameters: Phenol, Cyanide, Ammonia, Oil and Grease...... A. B. M. Shahalam, D. A. Burke (Jordan, U.S.A.)	118
C-80.	Modelling of Oxygen Depletion in Coastal Waters........................ A. Malmgren-Hansen, P. Mortensen, B. Moller (Denmark)	119
C-81.	Water Quality Modeling of the Lower Han River, Korea...................... L. F. Tischler, R. M. Bradley, S. J. Park, D. G. Rhee (U.S.A., Korea)	120
C-82.	A Role for a Simple Discrete-Time Model to Describe Dispersion in an Estuary............................... T. Wood (Australia)	124
C-83.	Tidal Variation of Salt Flux and Dispersion in a Polluted Estuary...... J. K. Park, A. James (United Kingdom)	125
C-84.	Factors Affecting the Adsorption of Complexed Heavy Metals on Hydrous Al_2O_3................................. H. A. Elliott, C. P. Huang (U.S.A.)	128
C-85.	Infrared Thermal Regeneration of Spent Activated Carbon from Water Reclamation........................... B. M. van Vliet, L. Venter (South Africa)	129

Number	Title and Authors	Page
C-86.	Organic Removal Mechanisms in Biophysical Treatment Systems......... J. R. Schultz, T. M. Keinath (U.S.A.)	130
C-87.	Ozone Enhanced Biological Activated Carbon Filtration and its Effect on Organic Matter Removal, and in Particular on AOC Reduction........... J. G. Janssens, J. Meheus, J. Dirickx (Belgium)	130
C-88.	Ozonation of Non-Ionic Surfactants in Aqueous Solutions...................... N. Narkis, B. Ben-David, M. S. Rotel (Israel)	131
C-89.	Influence of Bubble Sizes on Ozone Solubility, Utilization and Disinfection.......................... M. Ahmad, S. Farooq (Saudi Arabia)	134
C-90.	The Role of Rapid Mixing Time on a Flocculation Process.................. R. J. Francois, A. A. Van Haute (Belgium)	135
C-91.	Management of Urban Waste Water Physico-Chemical Treatment Stations: Servocontrol of Reagent Additions at the Quiberon Sewage Treatment Plant, France................................ P. Marchandise, J. P. Legendre, D. Delacroix, J. L. Rivoal (France)	136
C-92.	Modeling of the Coagulation-Adsorption Process in Treatment Systems.......... A. M. Dziubek, A. L. Kowal (Poland)	137
C-93.	Hexavalent Chromium Removal from Drinking Water........................ J. M. Philipot, F. Chaffange, J. Sibony (France)	137

Number	Title and Authors	Page
C-94.	The Contribution of Agricultural Loading to Eutrophication in Finnish Lakes................................. L. Kauppi (Finland)	140
C-95.	Modeling Water Quality and the Effects of Agricultural Best Management Practices in the Iowa River Basin...... B. R. Bicknell, A. S. Donigian, Jr., T. A. Barnwell (U.S.A.)	142
C-96.	Surface Water Quality in Relation to Soil Type, Land Use and Discharge in a Rural Catchment Area................ M. C. H. Witmer (The Netherlands)	144
C-97.	Chronic Pollution of Intercity Motorway Runoff Waters................ J. D. Balades, M. Cathelain, P. Merchandise, J. Peybernard, J. C. Pilloy (France)	147
C-98.	Collection and Analysis of Urban Runoff Data in Finland................ M. J. Melanen (Finland)	148
C-99.	Marine Quality Standards: Their Derivation and Application in the United Kingdom........................ G. Mance, A. R. O'Donnell (United Kingdom)	151
C-100.	The EEC Shellfish Directive in Wales.. S. N. Young, P. Wathern (United Kingdom)	152
C-101.	Operation and Efficiency of Automatically Operating Weir Structures--A Contribution to Cleaner Waters........................ E. Macke (Federal Republic of Germany)	153
C-102.	Sedimentation, Mineralization, and Resuspension of Sludge in a Sewerage System: A Case Study................. A. S. Hogendoorn-Roozemond (The Netherlands)	154

Number — Title and Authors — Page

Poster Presentations

P-1.* The Urban Water Research Project, Lelystad .... ---
F. van der Ven, E. Uunk (The Netherlands)

P-2. Surveying Tidal Fluxes of Metals Through the Mersey Narrows, 1982 & 1983 196
K. Whitelaw, J. Cole, P. Head, P. Jones (United Kingdom)

P-3. A Modular Water Treatment Package for Surface Waters in Rural Locations of Developing Countries Incorporating Novel Design & Operational Features... 180
D. Wheeler, M. Pardon, B. Lloyd (United Kingdom)

P-4. A Low Cost Portable Water Testing Kit for Developing Countries.......... 167
D. Wheeler, M. Snook, B. Lloyd (United Kingdom)

P-5. Investigations on the Anaerobic-Aerobic Treatment of a High Concentrated Wastewater............... 173
A. Mennerick (Federal Republic of Germany)

P-6.* Water Quality Models Based on Thermodynamics of Accumulation Processes Regularities.......................... ---
M. Mehandijiev (Bulgaria)

P-7. Evaluation of a Sludge Treatment Process with Thermal Conditioning..... 164
L. Spinosa (Italy)

P-8. A Fixed Bed Reactor and Stirred Reactor Compared in the Case of Anaerobic Wastewater Treatment........ 160
S. Kunst, K. Mudrack (Federal Republic of Germany)

---

*This poster was not presented or was not reviewed.

Number	Title and Authors	Page
P-9.	Chlorinated Phenols and their Derivatives in Soil and Groundwater Around Wood-Preserving Facilities in Finland.............................. R. Valo, V. Kitunen, M. S. Salkinoja, S. Raisanen (Finland)	198
P-10.	Upgrading of Existing Sewage Treatment Plants................................ T. Muller, J. Janus (The Netherlands)	169
P-11.	New Design Guidelines for Circular and Rectangular Final Settling Tanks.. R. Epskamp, F. Hernen (The Netherlands)	165
P-12.	Groundwater Pollution Resulting from the Disposal of Wastes in the 'Volgermeer polder' Situated North of Amsterdam.......................... J. van der Schroeff (The Netherlands)	181
P-13.*	Effect of Soil Particles and Autochtonous Particulate Matter on the Fate of Parathion in Water........ A. Gasith, D. Goldman, A. Perry (Israel)	---
P-14.	Algal Growth Potential Test: An Indicative Method to Estimate the Influence of Water Quality Changes on the Algae Biomass.................. G. Bolier (The Netherlands)	165
P-15.	Center for Water Quality Modeling..... T. Barnwell (U.S.A.)	161
P-16.	Prediction of Nutrients and Chlorophyll in the Future Freshwater Basin Volkerakmeer/Zoommeer, The Netherlands........................... G. van Eck, N. M. de Rooij (The Netherlands)	186

---

*This poster was not presented or was not reviewed.

Number	Title and Authors	Page
P-17.	Predictions of Micropollutants in the Future Freshwater Basin Volkerakmeer/Zoommeer, The Netherlands............. E. van der Vrie, G. van Eck, N. M. de Rooij (The Netherlands)	182
P-18.	Prediciton of Chloride in the Future Freshwater Basin Volkerakmeer/Zoommeer, The Netherlands....................... J. Bakker, N. M. de Rooij (The Netherlands)	194
P-19.*	Control of Salinity in the Coastal Groundwater of Indian Peninsular...... P. Basak, S. Abraham (India)	---
P-20.	The Lagoon of Santa Gilla (Sardinia): Present Conditions and Possibilities of Restoration....................... A. Contu, P. Mulas, G. Sarritzu, M. Schintu, N. Sechi, A. Ulzega (Italy)	169
P-21.*	Streambank and Instream Habitat Restoration of Foothills Creeks Affected by Oil and Gas Activities.... M. Polet, J. Allan (Canada)	---
P-22.	Optimization Modelling for the Selection of an Abatement Program for Diffuse Agricultural Pollutants....... J. Cousins, E. McBean (Canada)	196
P-23.*	Flotation and Membrane Treatment of Industrial Wastewaters................ O. Hart, R. Squires (South Africa)	---
P-24.*	Artificial Wetlands as Tertiary Wastewater Treatment Systems.......... J. de Jong (The Netherlands)	---
P-25.	Remineralization and Potabilization of Desalinated Water.................. Y. Henderyckx (Belgium)	179

---

*This poster was not presented or was not reviewed.

Number Title and Authors Page

P-26.* Study of Viral Pollution at the East Lake in Wuchang .... ---
Z. Chu-Yu (China)

P-27. Estimation of Mutagenic Activities and Physico-Chemical Indexes of Coastal Sea Waters 200
N. Kinae, M. Yamashita, T. Watanabe, M. Takahashi, S. Yamamoto, I. Tomita (Japan)

P-28.* Application of Stripping Voltammetry to Survey the Trace Metals in River Waters .... ---
B. Singh, S. Pathak (India)

P-29. Biological Treatment of Phenolic Wastewater in a Three-Phase Fluidized Bed 161
Y. Hosaka, M. Kaihou, A. Hirata (Japan)

P-30.* The Influence of Substances Polluting Water on Electrophysiological Indexes of Olfactory and Visual System of Fish ---
S. Tagier, A. Ismailov (United Soviet Socialist Republic)

P-31.* New Contribution on Surface and Subsurface Water Relationship in Egypt Using Radio Isotopic Model for the River Nile .... ---
B. Mabrook, F. Swelim, R. El Sheikh (Egypt)

P-32.* Fate and Effect of Copper on the Performance of a Rotating Biological Contactor .... ---
F. El Gohary, M. Lasheen, M. Saleh, A. Ashmawy (Egypt)

P-33. The Response of Aquatic Organisms to Mixtures of Toxicants 192
E. Christensen, C. Chen, J. Kannall (U.S.A.)

---

*This poster was not presented or was not reviewed.

Number	Title and Authors	Page
P-34.	Distribution of Suspended Particulate Matter Near Orange County, California, Sewage Outfall........................ R. Kolpack (U.S.A.)	201
P-35.	Dynamic Response of Final Clarifiers.. J. Dietz, T. Keinath (U.S.A.)	175
P-36.*	Boron Removal with Resin and its Formulation........................... D. Topacik, S. Sahin (Turkey)	---
P-37.	The Surfactant Profile of Municipal Wastewater: Influents and Effluents.. U. Zoller (Israel)	201
P-38.	Complete Reclamation of Wastewater and Sludge............................ B. Elkins, G. Wilson, R. Gersberg (U.S.A.)	175
P-39.	Environmental Acidification and its Consequences for the Toxicity of Weak Acids and Bases to Aquatic Organisms.. I. van der Putte, M. Brinkhorst (The Netherlands)	184
P-40.	Modelling the Phosphate Concentration in a Shallow Lake, with Special Emphasis on the Effects of Sediment-Water Exchange........................ P. Kelderman, A. Verwey (The Netherlands)	198
P-41.*	A Seasonal Study on the Distribution of Mercury in the River Cooum in Madras................................ K. Ayyadurai, V. Krishnasamy (India)	---
P-42.	Partial Extraction of Metals from Soil to Evaluate Pollution............ C. W. Randall, C. D. Donaldson, P. J. Wigington, T. J. Grizzard W. R. Knocke (U.S.A.)	189

---

*This poster was not presented or was not reviewed.

Number	Title and Authors	Page
P-43.*	Investigation for and the Design and Construction of a Submarine Outfall Pipeline into Bass Strait, Victoria, Australia............................. J. J. Ryan (Australia)	---
P-44.	Mass Transfer Mechanisms in a Heterotrophic Biofilm................. H. Siegrist, W. Gujer (Switzerland)	174
P-45.*	Aqueous Suspension Based Abrasion Resistant Assessment for Particulate Activated Carbons..................... M. Vennekens, B. van Vliet (South Africa)	---
P-46.*	Anoxic-aerobic Digestion of Waste Activated Sludge....................... A. Warner, G. Ekama, G. Marais (South Africa)	---
P-47.*	Axial Dilution in an Obstructed Round Vertical Turbulent Buoyant Jet.. G. Noutsopoulos, P. Yiannopoulos (Greece)	---
P-48.	Evaluation of Alternative Measures for Controlling Pollution in Part of West Morava River Basin.................... A. Filip, D. Obradovic (Yugoslavia)	187
P-49.	Recent Studies of Systems for Small Scale Wastewater Treatment in The Netherlands........................... J. van der Graaf, H. Webers (The Netherlands)	172
P-50.*	Modelling of Hypolimnic Water Quality in Deep Pits Created by Sand Dredging in the Lake IJssel Area............... J. van Pagee, J. Smits, J. de Wit (The Netherlands)	---

---

*This poster was not presented or was not reviewed.

Number	Title and Authors	Page
P-51.*	An Evaluation of Management Aspects of a Hypertrophic African Impoundment. J. Thornton, K. Cochrane, A. Jarvic, T. Zohary, R. Robarts, F. Chutter (South Africa)	---
P-52.*	Wastewater Treatment Using Aquatic Plants. Survivability and Growth of Salvinia Molesta Mitchell over Waters Treated with Zinc (II) and the Subsequent Utilization of the Harvested Weeds for Energy (Biogas) Production............................ S. Abbasi, P. Nipaney (India)	---
P-53.*	Biological Treatment of Industrial Wastewater in a Two-Staged Anaerobic Fluidized Bed Reactor................. J. Heijen, W. Enger (The Netherlands)	---
P-54.*	Application of the UASB Reactor for Anaerobic Treatment of Brewery Effluent.............................. P. Hack (The Netherlands)	---
P-55.	The Influence of Rainfall Characteristics on the Pollution Emission.............................. K. Bakker, H. S. J. van Wieringen (The Netherlands)	187
P-56.*	Wastewater Treatment Plants in Amsterdam............................. R. R. Kruize (The Netherlands)	---
P-57.	Lake Naarden Conservation Strategy Supply Water Treated in Special P-Removal Unit........................ E. L. C. Koster, P. L. Wuite, A. S. Hogendoorn-Roozemond (The Netherlands)	188

---

*This poster was not presented or was not reviewed.

Number Title and Authors Page

PRE-CONFERENCE SEMINAR ON FRESHWATER BIOLOGICAL MONITORING

Paper Presentations

1. Freshwater Biological Monitoring: Keynote Address........................ 204
J. Cairns, Jr. (U.S.A.)

2. The Performance of an Invertebrate Colonization Sampler in Biological Surveillance of Lowland Rivers........ 204
H. A. Hawkes, A. J. Watton (United Kingdom)

3. Use of Artificial Substrates for Standardized Sampling of Macroinvertebrates in the Assessment of Water Quality by Means of the Belgian Biotic Index.......................... 204
N. DePauw, D. Roels, P. Fontoura (Belgium)

4. Biological Surveillance in Welsh Rivers for Water Quality and Conservation Assessment............... 205
M. P. Brooker (United Kingdom)

5. Classification of Running-Water Sites Using Macroinvertebrates and Recent Attempts to Predict Species from Environmental Data.................... 206
J. F. Wright (United Kingdom)

6. Invertebrate Drift in the Biological Monitoring of Water Quality........... 206
F. M. Chutter (South Africa)

7. Early Warning of Eutrophication in Rivers by Analysis of Periphyton Chlorophyll a......................... 207
P. Heinonen (Finland)

8. Investigations into the Causes of Fishkills Occurring in the River Meuse (1979-1983)........................... 207
F. Van Hoof, W. Van Craenenbroeck, D. Marivoet (Belgium)

Number	Title and Authors	Page
9.	Assessing the Recovery of Two Coalfield Rivers: The Relationship Between Biology and Water Quality..... R. W. Edwards (United Kingdom)	207
10.	Aspects of Utilizing Continuous Automatic Fish Biomonitoring Systems for Industrial Effluent Control....... W. S. G. Morgan, P. C. Kuhn (South Africa)	208
11.	Automated Multispecies Biomonitoring Employing Fish and Aquatic Invertebrates of Various Trophic Levels...... E. L. Morgan, R. C. Young, C. M. Crane (U.S.A.)	209
12.	Toxicity Testing with Freshwater Macroinvertebrates. Methods and Applications in Environmental Management............................ K. Williams, D. Green, D. Pascoe (United Kingdom)	209
13.	Prediction of the Toxicity of Copper to Australian Freshwater Animals...... J. F. Skidmore, I. C. Firth (Australia)	210
14.	Fate and Effects of Chemicals in Outdoor Ponds Compared with Predictions Based on Laboratory Tests. N. O. Crossland (United Kingdom)	210
15.	Comparison of Biomonitoring Techniques for Evaluating Effects of Jet Fuel on Bluegill Sunfish (*Lepomis macrochirus*) T. R. Doane, J. Cairns, Jr., A. L. Buikema (U.S.A.)	211
16.	Intraspecific Variability to Stress Tolerance: Implications for Toxicity Testing.............................. P. Calow (United Kingdom)	212
17.	*Lemna* as an Indicator of Water Pollution and the Absorption of Heavy Metals................................ Y. Naus, M. Kugimoto, O. Tanaka, A. Takimoto (Japan)	213

Number Title and Authors Page

18. The Application of an Algal Assay to Assess Toxicity and Eutrophication in Polluted Streams.................. 213
T. Kallqvist (Norway)

19. Microbial Mutagenicity Testing of Water Samples......................... 214
P. Wilcox, H. Horth (United Kingdom)

20. The *Bacillus subtilis* Microsome Rec-assay for the Detection of Presence of Mutagens in Waters of a Municipal Wastewater Treatment Plant.. 214
S. Matsui (Japan)

21. Compliance Biomonitoring--Standard Development and Regulation Enforcement Using Biomonitoring Data.. 215
E. E. Herricks, D. J. Schaeffer (U.S.A.)

POST-CONFERENCE WATER VIROLOGY SEMINAR

Paper Presentations

1. Detection of Rotavirus in Treated Drinking Water........................ 218
B.H. Keswick, C.P. Gerba, J.B. Rose, G.A. Toranzos (U.S.A.)

2. Rotavirus Survival in Raw and Treated Waters and its Health Implications.......................... 228
S.A. Sattar, R.A. Raphael, V.S. Springthorpe (Canada)

3. Analysis of Tap Water for Viruses: Results of a Survey................... 219
N. Guttman-Bass, B. Fattal (Israel)

4. Viruses and Bacteria in a Chalk Well.. 219
J.S. Slade (United Kingdom)

5. Detection and Health Risk Associated with Low Virus Concentration in Drinking Water....................... 220
P. Payment, M. Trudel (Canada)

Number Title and Authors Page

6.* Coliphages and Enteroviruses in Wastewater Effluents and the Immune Status of Occupationally Exposed Wastewater Treatment Plant Workers.... ---
A. Simkova, A. Petrovicova
(Czechoslovakia)

7. Concentration of Seeded and Naturally Occurring Enteroviruses from Waters of Varying Quality by Hollow Fiber Ultrafiltration........................ 232
E.A. Bicknell, D.M. Dziewulski,
L.S. Sturman, G. Belfort (U.S.A.)

8. The Recovery of Viruses from Drinking-water by Means of an In-line Electropositive Cartridge Filter............. 233
E.M. Nupen, B.W. Bateman
(South Africa)

9. Concentration of Viruses from Water Using Pig Erythrocyte Ghost Cells..... 234
R. Armon, Y. Kott, Y. Neeman
(Israel)

10. Bacteria and Viruses in Aerobically Digested Sludge: Influence of Physical and Chemical Treatments on Survival and Association with Flocs under Laboratory Conditions........... 223
S.R. Farrah, P.R.Scheuerman,
R.D. Eubanks, G. Bitton (U.S.A.)

11. Virus Inactivating Effect of Anaerobic Mesophilic Digestion of Municipal Sewage Sludge without or with Different Preceding Types of Treatment............................. 224
M. Leuze, M. Saier, K. Koch,
J. Wekerle
(Federal Republic of Germany)

---

*This paper was not presented or was not reviewed.

Number	Title and Authors	Page
12.	Detection and Stability of Enteric Viruses in Sludge, Soil and Groundwater............................ P.H. Jorgensen, E. Lund (Denmark)	228
13.	Interactions Between Biotic and Abiotic Factors and Viruses in a Water System.......................... R. Walter, H. Grahneis, J. Durkop, L. Broschinski (Federal Republic of Germany)	229
14.	Detection of Enteroviruses: An Assessment of Ten Cell Lines.......... R. Morris (United Kingdom)	234

Poster Presentations

Number	Title and Authors	Page
V-1.	The Influence of Isoelectric Point on the Inactivation of Viruses by Chlorine.............................. G. R. Taylor, M. J. Butler (United Kingdom)	225
V-2.*	Virological Research on Behalf of the Netherlands Waterworks................ M. van Ophen, E. van de Baan (The Netherlands)	---
V-3.*	Reduction of Viruses in River by Storage in Open Reservoirs............ M. van Olphen, J. G. Kapsenberg, E. Van de Baan, A. Franke (The Netherlands)	---

---

*This poster was not presented or was not reviewed.

Number **Title and Authors** **Page**

V-4. Detection of Indigenous Enteric Viruses in Raw Sewage Effluents of the City of Athens (Greece) during a Two Year Survey...................... 229
V. Krilelis, N. Spyrou, C. Serie (Greece)

V-5. Failure to Detect Cytopathic Enteroviruses in Drinking Water....... 221
R. Morris, D. N. Sharpe, (United Kingdom)

V-6. Behaviour of Coliphages in Oxidation Ponds.................................. 226
T. Omura, H. K. Shin, A. Ketratanakul (Japan)

V-7.* Reduction of Viruses in River Water by Storage in Open Reservoirs......... ---
M. van Olphen, J. G. Kapsenberg, E. Van de Baan, A. Franke (The Netherlands)

V-8. Detection of Hepatitis A Virus (HAV) in Drinking Water..................... 221
M. D. Sobsey, S. E. Oglesbee, D. A. Wait (U.S.A.)

V-9. Examination of the Penetration of Enteric Viruses in Soils Under Simulated Conditions in the Laboratory 230
P. H. Jorgensen (Denmark)

V-10.* Efficiency of Coagulation on Filter and Settling in Relation to Indigenous Virus Removal from Water: Effect of Prechlorination....................... ---
M. Conan, J. C. Joret, A. Hassen, F. Agbalika, Y. Richard, P. Hartemann (France)

---

*This poster was not presented or was not reviewed.

Number	Title and Authors	Page
V-11.	Study of Indigenous Virus Removal at Different Stages in an Industrial Treatment Plant Producing Drinking Water from River Water................ F. Agbalika, P. Hartemann, J. C. Joret, A. Hassen, M. Bourbigot (France)	226
V-12.*	Virus Removal by Activated Sludge Treatment.............................. E. Shimohara, S. Sugishima, M. Kaneko (Japan)	---
V-13.	Studies on the Survival of Viruses in Fully Digested Sludge after Application to Grazing Land........... A. Field, J. Sellwood (United Kingdom)	230
V-14.	Some Experimental Discussion of Accuracies in Quantitative Virus Assessment for Water Supply........... H. Sumitomo, A. Kimura, T. Nakano, M. Ozaki, J. Imai (Japan)	222
V-15.	Detection of Hepatitis A Virus in Drinking Water by Enzyme-immunoassay Using Ultracentrifugation for Virus Concentration......................... A. Schnattinger (Austria)	235
V-16.	Genomic Analysis of RNA Viruses from Effluent.............................. M. T. Hodgkiss, J. W. Moodie (South Africa)	235
V-17.	Inactivation of Hepatitis A Virus by Heat and Formaldehyde................. B. Flehmig, A. Billing, A. Vallbracht, K. Botzenhart (Federal Republic of Germany)	231

---

*This poster was not presented or was not reviewed.

Number Title and Authors Page

POST-CONFERENCE SEMINAR ON ADVANCE TREATMENT TECHNOLOGIES FOR REMOVAL AND DISPOSAL OF MICROPOLLUTANTS

1. Presidential Address by Van Haute..... 242
(Belgium)

2. Removal of Traces of Arsenic and Selenium by Activated Alumina......... 243
M. Ghosh, J.R. Juan, R. Schlicher, S.M. Hornung (U.S.A.)

3. Two Options for Treatment of Acidic Organic Industrial Wastes............. 243
N. Millot, N. Dalga, N. Foussard (France)

4. Heavy Metal Removal in the Presence of Colloid-Stabilizing Organic Material and Complexing Agents........ 244
I. Licsko, I. Takacs (Hungary)

5. Changes in Particle Size Distributions on a Fixed Bed of Granular Activated Carbon................................ 245
E.A. Shpirt, K.T. Alben (U.S.A.)

6. Treatment of Tar Sand Wastewaters with Activated Carbon, Ozone and Reverse Osmosis........................ 245
R.A. Sierka, P.H. King (U.S.A.)

7. Water Treatment by Means of Activated Carbon, Prepared from Locally Available Waste Materials (II)........ 247
H. Keirsse, F. Van Hoof, J. Janssens, A. Buekens (Belgium)

8. Elimination of Micropollutants by $NaAlO_2$ Flocculation During Primary Treatment of Mixed Wastewater. 247
J. P. Vanderborght, R. Wollast (Belgium)

9. Upgrading of a Wastewater Treatment Plant in a Chemical Factory........... 247
P. Benedek, I. Takacs, I. Vallai (Hungary)

Number	Title and Authors	Page
10.	Impact of Selected Pretreatments on the Quantity and Distribution of Organic Halide Precursors............. D. Reckhow (U.S.A.)	248

EXECUTIVE SUMMARY

The International Association on Water Pollution Research and Control (IAWPRC) has sponsored biennial conferences since the first was held in London in 1962. These conferences have provided a forum where international researchers and practitioners can meet, present technical papers, discuss these presentations and debate technical issues of the times. Such conferences have provided an excellent format to exchange information relating to water pollution research and control, to develop personal insights as to problems and needs in countries of IAWPRC members, and to formulate personal and technical relationships between individuals from these countries.

The 12th International Conference on Water Pollution Research was held in Amsterdam on September 17-21, 1984. This report summarizes the formal and informal developments which evolved during this biennial conference and pre- and post-conference seminars. The document was prepared for the U.S. Environmental Protection Agency by the United States of America National Committee for Representation of the United States (USANC) to the International Association on Water Pollution Research and Control.

Rather than include complete conference papers with formal and informal floor discussion, many of which are published in Water Science & Technology, this report includes summary presentations as prepared by official U.S.A. participants in the conference. Specific emphasis was placed on those topics which were deemed to be of special interest to U.S.A. researchers and practitioners. Basic themes for this conference included ground water pollution and recharge, water quality problems, river and lake management, wastewater treatment and disposal, sludge treatment and disposal, stormwater and runoff management and control, treatment and reuse of industrial wastewater.

Some salient findings in this report, together with the originating countries, are as follows:

-- use of a diffusion reactor model to investigate the transport of organic particulates to aerobic biofilms (Denmark, Sweden).

-- use of sequenced biological systems including aerobic, anoxic and anaerobic steps to enhance organic removal (South Africa, U.S.A., Japan).

-- use of a phosphate-rock bed receiving wastewater containing seed crystals to chemically remove phosphorus from a wastewater without a corresponding production of sludge (Japan).

-- removal of phosphorus from biologically treated wastewater accomplished by precipitation of calcium phosphate on the surface of sand grains in a fluidized bed reactor (The Netherlands).

-- polyphosphates of both low and high molecular weights accumulated in the sludge of an anaerobic-anoxic process with the low molecular-weight fractions mostly responsible for release and uptake of phosphorus (Japan).

-- anaerobic treatment of diluted coal-gasification wastewaters was demonstrated with specific emphasis on removal of phenols and cresols (Canada).

-- techniques based upon return sludge recycle containing a tracer were developed for measuring short circuiting in oxidation ditches (Federal Republic of Germany).

-- presentation of a multiple level model for the activated process where effluent concentrations depended on model level while biomass concentrations were unaffected by model choice (Israel, Japan).

-- several kinetic models for the activated sludge process related kinetics to the type of microorganisms generated and the type of organics being degraded (U.S.A.).

-- the effect of Thiothrix on sludge bulking and activated sludge plants was defined with emphasis on the significance of sulfide and thiosulfate oxidation under aerobic conditions (Denmark).

- a method for predicting inhibitory impacts of multiple toxicants on biological systems (U.S.A.).
- a model for fluidized bed nitrification was developed and compared to laboratory-scale reactor data (Canada, U.S.A.).
- modeling of competitive heterotrophic/autotrophic activity in rotating biological contactors used for denitrification (Japan).
- use of degree of nitrification as a surrogate measure of trace-contaminant removal (Canada).
- a model for fluidized-bed biological denitrification included intermediate formation of nitrites (The Netherlands).
- influence of chelates, pH and background ions on adsorption of metallic ions onto aluminum oxide (U.S.A.).
- an infrared conveyor belt furnace providing quantitative residence time, temperature and furnace atmosphere control capability reported to be effective for regeneration of spent activated carbon (South Africa).
- effect of temperature on regeneration of activated carbon with respect to diminishing the extent of micropore restoration was illustrated (South Africa).
- effect of addition of powdered activated carbon to activated sludge systems on enhanced rate and extent of biodegradation of phenols (U.S.A.).
- examination of ozone application prior to granular activated carbon treatment indicated the cost of this ozonation could not be reconciled by overall cost savings (Belgium).
- ozone treatment alone was not feasible for total removal of non-ionic surfactants from waste streams, but partial ozonation made them more amenable to subsequent biological treatment (Israel).

-- optimization of ozone-bubble size to maximize both treatment effectiveness and ozone utilization (Saudi Arabia).

-- use of ferric-sulfate addition and filtration for removal of hexavalent chromium (France).

-- use of anion exchange resins to remove iron cyanide from both synthetic and actual gold-mill effluents (Canada).

-- wet oxidation effective in treating highly concentrated organic wastewaters to acceptable levels (France).

-- effects of inevitable particle-size changes on adsorption kinetics and fluid mechanics in packed bed activated carbon columns (U.S.A.).

-- use of activated alumina as adsorbing media for removing arsenic and selenium (U.S.A.).

-- sodium aluminate addition as a potentially effective technique to alleviate heavy-metal inhibition of biological treatment (Belgium).

-- a fluidized-bed precipitation reactor to treat radium in uranium mining effluents (Canada).

-- inactivation of enteric viruses using mesophilic sludge digestion followed by pasteurization (Federal Republic of Germany).

-- detection of low levels of enteric viruses in drinking water supplies (Israel, Canada).

-- migration of viruses into ground water resulting from land disposal of sludges (Denmark).

-- a new system capable of detecting F-specific coliphages in water and wastewater; based on attack of a host bacterium (The Netherlands).

-- inactivation of polio virus using chlorination near the isoelectric point (United Kingdom).

-- artificial wetlands shown capable of treating primary effluents to secondary-treatment levels of BOD and suspended solids (U.S.A.).

- use of sludge volume index (SVI) in design and operation of secondary clarifiers using empirical relationships between SVI and sludge flux theory (South Africa).
- an approach to quantify the stability of particles in lakes presented to permit an estimate of stability in lakes of varying chemical and physical characteristics (U.S.A.).
- a comprehensive discussion of models used to predict water quality of new lakes affected by pollutants from agricultural sources (The Netherlands).
- water quality models developed for use in complex ecological systems require accurate biological components in order to provide a foundation for any prediction made with model (United Kingdom).
- artificial substrate samplers shown to be valuable macroinvertebrate collection devices (United Kingdom, Belgium).
- algal assays and analysis of mutagenic responses in bacteria are valuable biomonitors (Norway, United Kingdom).
- treatment of palm oil and natural rubber processing wastewaters with water hyacinths (Malaysia).
- the sediment-water exchange of phosphate in a shallow lake modeled as a function of temperature and phosphate concentration of the overlying water (The Netherlands).
- modeling of nonconventional water quality parameters, such as phenols, cyanides and oil and grease, handled kinetically in the same manner as conventional parameters using the transport-degradation processes of volatilization, absorption, hydrolosis and microbial degradation (Jordan, U.S.A.).
- models developed to predict average water quality of large estuary segments reduce data-procurement efforts as compared with rational finite-element models based upon material-balance principles (Australia).

The individual platform-presentation and poster sessions from which many of the above highlights were derived are discussed in Chapter II and include a description of the individual papers, a critique of the session, and the significance of the session findings to U.S.A. water pollution research activities. Reports of the pre-conference and post-conference seminars also highlighted above, are presented in Chapter III.

An overview of pertinent conference developments is presented in Chapter IV. Developments at formal sessions cover aerobic films, activated sludge, biological nitrification and denitrification, biological phosphorus removal, chemical phosphorus removal, physical-chemical treatment, disinfection and virology, land treatment, sludge treatment and disposal, anaerobic treatment, use of mathemathical models, eutrophication, natural systems, resuspension and sedimentation of particulates, benthal deposits, analytical procedures, collection systems and biomonitoring. The report closes with a description of important research and control developments throughout the world, noted by the cooperative-agreement participants outside the formal sessions during discussions with the conferees and visits to nearby laboratories.

CHAPTER I

INTRODUCTION

Background

The International Association on Water Pollution Research and Control (IAWPRC) is a non-governmental professional organization with the goal of advancing water pollution research worldwide to enhance the quality of the earth's water resources. Through conferences, workshops, symposia, and publications, e.g., Water Research and Water Science and Technology, IAWPRC provides a means for international communication of research results and new information relative to water quality control. The organization is governed by representatives on national committees of member countries. Each national committee, as a condition of membership in IAWPRC, represents the water quality research-related activities in the respective country; currently, 29 countries are members of IAWPRC.

The United States of America National Committee (USANC) is recognized by IAWPRC as the national organization representing U.S.A. water quality research interests in IAWPRC. USANC is sponsored by six major professional organizations with interest in water quality research: American Chemical Society; American Institute of Chemical Engineers; American Society for Microbiology; American Society of Civil Engineers; Association of Environmental Engineering Professors; and Water Pollution Control Federation. Each organization provides a modest amount of financial support to USANC for membership in IAWPRC and appoints two delegates and two alternate delegates to serve on USANC.

IAWPRC has sponsored biennial international conferences since 1962. Prior to the Twelfth International Conference in Amsterdam, The Netherlands, September 17-21, 1984, conferences were held in London, Tokyo, Munich, Prague, San Francisco, Jerusalem, Paris, Sydney, Stockholm, Toronto and Cape Town. The 1986 Conference is scheduled for Rio de Janeiro. The conferences represent the largest international gathering of research engineers and scientists, consulting engineers, manufacturers of process control equipment, administrators of water quality control programs and others involved in water quality control.

The purpose of this report, prepared by USANC for the Office of Research Grants and Centers, U.S. Environmental Protection Agency, is not to present a verbatim record of the Conference. Papers, poster presentations, and pre- and post-conference seminars with formal and informal floor discussion and response from authors, will be published as a Proceedings in Water Science and Technology. Rather the purpose of the report is to present a timely and critical analysis of formal and informal developments at the Conference which are of potential interest to EPA. The report represents an assessment by U.S.A. participants of significant conference developments. Contributions of individual authors from various countries of the world are considered in the context of the reception which they received from discussers and the international audience. The analysis is not limited to formal conference developments, but includes developments from the informal exchanges between engineers and scientists from various countries which inevitably occur outside formal conference sessions.

The technical program for the Amsterdam Conference was developed by the Program Committee of IAWPRC from papers submitted from around the world in response to an invitation to submit papers covering a wide range of subjects, e.g., water quality problems, river and lake management, ground water pollution and recharge, wastewater treatment and disposal, sludge treatment and disposal, stormwater and runoff management, and control, treatment and reuse of industrial wastewater. Reprints of papers selected for the program were available to participants in advance of the Conference, and only abbreviated summaries of the papers were presented by the authors in Amsterdam. Formal discussers were selected prior to the Conference to prepare critical analyses of each paper. Additionally, appreciable informal discussion of the papers and of the formal discussions occurred. Appendices A and B contain the programs for the Conference and pre- and post-conference seminars and provide additional information on the conduct of the sessions.

Report Development

This report was prepared by those U.S.A. participants in the Amsterdam Conference who presented papers, presented formal discussions of research presentations, chaired or recorded sessions and seminars, and participated in IAWPRC Governing Board activities and who elected to participate in the project. Development of the report was coordinated by a Coordinating Subcommittee of USANC consisting of USANC officers for 1982-1984 (F. G. Pohland, Chairman, R. S. Engelbrecht, Vice-Chairman; R. A. Conway, Secretary-Treasurer).

Prior to the Conference, the USANC Coordinating Subcommittee ascertained the interest of Conference participants in contributing to the developments of this report and solicited expressions of interest in reviewing particular sessions at the Conference (Appendix C). Assignments for coverage of all the sessions were then made as indicated in Appendix D. Appendix C contains the instructions given to participants for the development of this report.

Reports by the individual participants are included in Chapters II and III. Aside from minor editing to render the reports compatible with the general format and to eliminate items unrelated to water quality research, the reports are published here as received from the authors. Thus, the reports represent a critical assessment by U.S.A. water quality control researchers and other professionals of those Conference sessions which received their special attention. Individual reports appear under the by-line of the reviewers and represent their personal views--not necessarily the views of the Coordinating Subcommittee or USANC.

Highlights of Chapters II and III, as perceived by the reviewers and the Coordinating Subcommittee, are summarized in Chapter IV. In addition, information submitted by individual participants on developments at the Conference unrelated to their sessions are summarized in Chapter IV. The Executive Summary is an abbreviated version of Chapter IV.

Users of the report will find the Table of Contents together with the Key to Reviews useful in locating in Chapters II and III the discussions of particular papers, poster presentations, or pre- and post-conference seminars. Additionally, Appendices A and B should be useful in gaining a perspective on the Conference and on the contents of Chapters II and III.

CHAPTER II

CONFERENCE SESSION REPORTS

1. SESSION

   A. Day: Monday, September 17, 1984
   Location: Hall 1
   Time: 2:00-5:25 p.m.

   B. Theme of Session: Aerobic Films

2. REVIEWER

   A. Name: Francis A. DiGiano

   B. Position and
   Affiliation: Professor of Water Resources Engineering, University of North Carolina, Chapel Hill, North Carolina (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-1: "Removal of Soluble Substrates in Fixed Films" by J. la Cour Jansen and P. Harremoes (Denmark).

La Cour Jansen (Denmark) presented experimental data to verify a biofilm model that had been previously published by the second author (Harremoes). The model is identical to that described by LaMotta in the U.S.A. in 1974 (his work was referenced in this paper). It made the critical assumption that Monod kinetics can be simplified for many substrates such that zero-order holds. This point was contended in subsequent discussion of the paper. Although research by Williamson and Meunier (Env. Eng. Div., ASCE, April 1981) in the U.S.A. was not referenced, it is very important because it addresses dual substrate limitation (electron acceptor and electron donor) and provides a more general mathematical framework than given by these authors.

The strength of the paper was in the presentation of experimental data for denitrification and for aerobic organic removal. Not surprisingly, the data confirmed the well-known observation that the concentration of oxygen adjacent to the biofilm most often limits the reaction rate unless the electron donor concentration is very low. The data also supported the dual substrate limitation concept in which the shift in rate limitation from electron acceptor to electron donor occurs as the concentration of the electron donor is lowered. The donor concentration that denotes the switch from acceptor to donor limitation was empirically found from a plot of the rate data. The Williamson and Meunier model, on the other hand, presents a predictive procedure that is of more general use.

A weak point of the model was the variability in predicted biofilm diffusivities. The authors conjectured that differences in structural features of the biofilm and electrostatic interactions between ions and fixed charges are responsible for this anomaly but no evidence was provided.

The official discusser, Olson (U.S.A.), was not present. However, Wanner and Gujer (Switzerland), authors of Paper No. C-3, precipitated more general discussion of the philosophy of biofilm modeling. They questioned the tacit assumption that the half-saturation constant was not important and that zero-order kinetics could be used. Harremoes (Denmark) made the very telling point that, while diffusional theory was introduced ten years ago to give a more sound theoretical basis for biofilm behavior than the simple, first-order models, there has been little use of this concept in design practice. This is because the concept is too theoretical for many engineers. Therefore, simplifications as proposed by Harremoes (Denmark) provide a chance of adaptation in practice. At the same time, the authors admit that, for certain substrates and concentration ranges, their simplifying assumption of not including the half-saturation constant may not work.

B. Paper No. C-2: "Influence of Particulate Organics on the Removal of Dissolved Organics in Fixed-Film Biological Reactors" by E. Sarner and S. Marklund (Sweden)

Sarner (Sweden) reported on laboratory research aimed at determining the effect (positive or negative) of particulates on the substrate removal rate in biofilms. Starch and digested sludge were used as the sources of particulates and glucose was used as the soluble substrate on which the biofilm was established. The amount of particulates adsorbed was difficult to control. This was a source of unwanted variability in the experiments. Moreover, the feed glucose concentration and temperature varied from experiment to experiment. A simple statistical approach was used to compare the removal of glucose in the presence and absence of particulates at the various temperatures and feed glucose concentrations. The major conclusion was that particulates only inhibited the removal of glucose in experiments at the higher temperatures (15-20°C), although evidence for this effect was weak. No satisfactory explanation was given for a somewhat positive effect at lower temperatures (5-10°C). The paper left many unanswered questions primarily because too many variables were not well controlled.

The official discusser, Molof (U.S.A.), was critical of the paper because of the lack of control in experiments. However, more general discussion focused on the importance of understanding the fate of particulates in the biofilm. It was pointed out that in practice much of the organic substrate matter is actually colloidal and, therefore, undergoes adsorption onto the biofilm before biodegradation. This paper was a start in the right direction, but revealed many difficulties in experimental design that must be resolved.

C. Paper No. C-3: "Competition in Biofilms" by
O. Wanner and W. Gujer
(Switzerland)

A new mathematical model was presented by Wanner (Switzerland) to accommodate the simultaneous growth of different microorganisms that compete for the same electron donor. The paper gave simulations of biofilm activity, but did not provide experimental verification. The model coupled the well-known diffusion-reaction concept of the biofilm with a new description of the flux of microorganisms within the biofilm; as microorganism grow, an equivalent mass is released into the bulk liquid to maintain a constant biofilm thickness.

The practical example selected for simulation was simultaneous growth of autotrophs and heterotrophs in a biofilm for which organic substrates and ammonia are being removed and oxygen is the common electron donor. The model showed that the COD and ammonia concentrations defined competition in the biofilm. The faster growing heterotrophs were shown to predominate at the top of the filter, and the slower growing autotrophs in the lower portion. Thus, field observations of the preferential removal of COD at the top and ammonia in the lower depths were explained by the model.

The model also gave the composition of the biofilm at any depth in a trickling filter. For any combination of concentrations, the model showed that the heterotrophs predominate in the outer region of the biofilm thickness and the autotrophs in the inner region. The product of metabolic activity, i.e., the inert solids, accumulated in the innermost anaerobic region. The autotrophs do not seriously retard the growth of heterotrophs and thus do not slow the biodegradation rate. They do, however, greatly influence the rate of oxygen consumption (as could be reasoned from stoichiometric considerations). The model showed, moreover, that the activity of autotrophs is greatly affected by the heterotrophs.

The official discusser, Watanabe (Japan), presented his own data for an RBC that showed the oxygen flux as independent of the composition of organisms in the biofilm which is unlike the competitive model results. Other than this discrepancy, the discusser was in total agreement with the paper's conclusions. As a general comment, the authors pleaded for more cooperation between modelers and experimentalists so that model verification could go forward. Other discussers, most notably Harremoes (Denmark), were very enthusiastic about the paper. The discussion shifted to the several ways of conceptualizing the biofilm growth process in models (e.g., sloughing, mechanical shear, constant biofilm thickness, expanding biofilm thickness) and which of these is actually correct. There is still little fundamental knowledge of this elementary aspect of the biofilm process.

D. Paper No. C-4: "The Effect of Load Fluctuations on the Effluent Concentration Produced by Fixed-Film Reactors" by B. E. Rittman (U.S.A.)

The paper emphasized biofilm modeling to describe load fluctuations expected in wastewater treatment. The model assumed that the steady-state, diffusion-reaction model defines the mass of biofilm at any location along the length of the reactor at the average loading and remains constant during load fluctuations. This assumption raised some questions in later discussion. The response to unsteady-state was described by an existing model reported earlier by Rittmann and McCarty (U.S.A.). Like Paper No. C-3, only theoretical calculations were presented. Several different loading scenarios were analyzed in which flowrate, influent substrate concentration, or both were increased and decreased over the average values and the weighted average effluent concentration calculated by the model.

Unfortunately, the discussion of this paper showed that at least some of the participants were confused about the modeling approach presented in this paper and in particular, the use of the first-order kinetic model. Some had falsely concluded that the author was recommending use of a first-order model. In fact, the diffusion-reaction biofilm model provided the steady-state effluent substrate concentration from which an apparent first-order rate constant was calculated for each loading scenario. No mention was made in the paper as to whether the substrate concentration profile throughout the reactor actually fits the first-order expression. The first-order rate constant was used to generate a weighted average effluent substrate concentration for the unsteady-state loading scenario which was then compared to the prediction from the diffusion-reaction model. There was fairly good agreement between the predictions for the two models, although this point was not stressed in the paper. However, from a phenomenological viewpoint, the results clearly indicated that the first-order model was not appropriate because the rate constant did not remain constant for all of the changes in loading conditions.

The official discusser, Pretorius (South Africa), mentioned that while the model was interesting, the results were obvious from the start and defeated the purpose of modeling. That is, changes in loading to a reactor are expected to produce changes in effluent quality. However, as the author pointed out, the model is able to distinguish which types of loading fluctuations affect effluent quality the most, and thus it provides more information than intuitive reasoning. For example, the greatest deterioration in effluent quality was found when both the flowrate and influent substrate concentration were either increased or decreased simultaneously. The most resistance to change in effluent quality was offered by the reactor which was most highly loaded at steady state.

E. Paper No. C-5: "Evaluation of Temperature Effects on Trickling Filter Plant Performance" by A. Adin (Israel), E. R. Baumann (U.S.A.) and F. D. Warner (U.S.A.)

The proposed model presented by Adin (Israel) assumed that the effect of temperature on removal of suspended solids (SS) and biochemical oxygen demand (BOD) in primary sedimentation can be explained through the viscosity term in Stoke's law which is used to determine the discrete settling velocity; thus the model simply states that removal efficiency increases linearly with increasing temperature. For removal in a trickling filter, the model for temperature effect is the van't Hoff-Arrhenius equation with the assumption that biochemical oxidation is a first-order reaction rate (previous papers in this session had solidly supported the use of the diffusion-reaction model). The overall treatment efficiency was analyzed as a function of temperature by combining these two mathematical relationships.

The resulting model was then tested with field data; a statistical analysis gave the best fit values for the four temperature constants (two each for primary sedimentation and a trickling filter). Although the authors were encouraged by the fit of the model to the data, their efforts could not be considered entirely successful. Taken separately, the efficiency of the sedimentation process was not well described even though the overall process efficiency was better described. Also, the success of modeling effort depended upon location in the plant where temperature data were taken; raw wastewater temperature was found unreliable, but no fundamental explanation was offered.

The official discusser, Wheatland (United Kingdom), considered the proposed model as far too simplistic to explain temperature effects. He pointed out that density currents in primary sedimentation occur at very low temperature differentials, and these influence the sedimentation process greatly. Moreover, data from the discusser's laboratory showed that the BOD loading influenced the temperature dependence of BOD removal. Temperature was not important at low BOD loadings but was at high BOD loadings. Finally, the discusser expressed concern over the lack of experimental detail, especially the absence of BOD loading data and the compositing procedure used to obtain data for model verification. The author's response to the issues raised by the discusser was not very satisfying. He agreed, however, that density currents could be important. He also explained that the BOD loading information was available but was not included in the paper due to a constraint on length.

4. CRITIQUE OF SESSION

Two papers focused entirely on advancing the understanding of the biofilm through mathematical modeling, while the others offered verification of conceptual development with laboratory and field data. Not all of the experimental systems were well enough defined, however, to provide convincing support for the postulations presented. One of the weaknesses in this area of research was the lack of good experimental data to verify models. During discussion of one paper, a plea was issued for more cooperation between experimentalists and modelers.

Paper No. C-3 was the most interesting because it provided a new conceptual framework with which to view the distribution of microbial populations in the biofilm and the consequence of this in the practical situation where competition exists for the same electron donor (e.g., oxygen in the case of nitrification and carbonaceous BOD removal). The model offers potential to investigate various forms of competition in biofilms; however, experimental data are needed for verification. This paper precipitated the most thought-provoking discussion of biofilm theory of the entire session.

Paper No. C-5 was also an interesting mathematical modeling exercise, although not well understood by some of the audience. Its main thrust was to show that information can be gained through a simplified approach to modeling of the unsteady state caused by load fluctuations while still maintaining the proper fundamental description of the biofilm. While researchers may be dissatisfied with their level of fundamental understanding of the steady-state situation, the unsteady-state situation is nevertheless an important direction for the future.

Paper No. C-2 opened an important area for research; the effect of particulates on the biofilm process. While the experimental data were not convincing, the difficulties inherent in such an experimental design were well recognized.

Paper No. C-1 did not present any new concepts about biofilms. However, the ensuing discussion focused mainly on differences in philosophy of modeling and this was very beneficial. In particular, insight was given into the role of models in practice and the appropriate level of sophistication for adoption of models in design.

Paper No. C-5 came the closest to practice by incorporating field data into a modeling effort aimed at explaining the effect of temperature on trickling filter performance. Unfortunately, this paper fell short of providing convincing evidence that the model was appropriate.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The session included some new and very interesting areas of research (competition in biofilms, unsteady-state behavior of fixed-film reactors and sorption of particulates onto biofilms) that should stimulate more work. At the very least, many of these papers increased one's appreciation of what is unknown about the biofilm process. There is worldwide interest in biofilm technology for a range of applciations. It is logical, therefore, to encourage more research given that much less is known about attached growth than suspended growth systems and that the attached growth systems offer significant advantages. Closer international cooperation should be encouraged, especially between experimentalists and modelers.

There is some disagreement over the level of sophistication needed in biofilm modeling. Most of the papers incorporated the diffusion-reaction model for description of substrate removal by biofilms. This shows the impact of research over the last ten years by several groups in the U.S.A. and in Europe which has led to an acceptable framework for conceptualization of the biofilm process. However, clear demonstration that this conceptualization of the biofilm process results in better design and process control than conventional methods is still missing.

1. SESSION

   A. Day: Tuesday, September 18, 1984
   Location: Hall 1
   Time: 9:00 a.m. to 12:25 p.m.

   B. Theme of Session: Phosphorus Removal

2. REVIEWER

   A. Name: Clifford W. Randall

   B. Position and Affiliation: The Charles P. Lunsford Professor of Civil Engineering, Virginia Polytechnic Institute and State University, Blacksburg, Virginia (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-6: "The Role of an Anaerobic Stage on Biological Phosphorus Removal" by T. Fukase, M. Shibata and Y. Miyaji (Japan)

This paper described both batch and continuous-flow experiments designed to investigate and elucidate the role of the anaerobic stage in an activated sludge system designed to achieve enhanced biological phosphorus removal. The experimenters developed parallel systems that were accomplishing enhanced phosphorus removal and then changed the operation of one until it ceased to achieve enhanced removal such that the two systems could be compared. The primary intent was to compare the respective abilities of poly-P and non-poly-P activated sludge microorganisms to remove BOD and synthesize poly-B-hydroxybutyrate (PHB) under anaerobic conditions.

The results showed that, although the amounts of phosphorus removed by the two systems were very different, the two sludges removed approximately the same amount of BOD and synthesized the same amount of PHB. Changes in ATP were also similar. The authors concluded that the anaerobic-aerobic reactor configuration was not sufficient, in itself, for the development of an enhanced phosphorus accumulating activated sludge culture. They also concluded that stored polyphosphates are not essential to bacteria for removal of BOD in the anaerobic reactor and, therefore, the polyphosphate-containing microorganisms have no competitive advantage over other microorganisms in the anaerobic reactor.

It is the opinion of the writer (Randall, U.S.A.) that the experimental design of this investigation was flawed and that most of the conclusions are misinterpretations. The authors stated that there was no difference in operational conditions between the phosphorus removing and the non-phosphorus removing systems except for the flow rate of the influent dilution water. That is to say, the organic loading rate was the same. However, the data in Table 4 indicated that that was not true. The data showed the MLVSS concentrations during the experiments to be very similar. Yet, the sludge age of the phosphorus removing system was reported as 14 days, while the sludge ages of Phases 2 and 3 of the non-phosphorus removing system were 54 and 29 days, respectively. The sludge age differences are inconsistent with the measured MLVSS concentrations indicating that either the reported data were bad or the operating conditions were erroneously described.

It should be noted that the differences in reported sludge ages were enormous in terms of bacterial population selection processes. During Phase 2, Unit B was operated deeply in the endogenous phase. This would have offset any potential advantage of the anaerobic-aerobic reactor sequencing arrangement to the polyphosphate accumulating microorganisms, because oxidized compounds such as nitrate would have recycled to the anaerobic unit, and the substrate available per unit mass of sludge would have been very small. Because of the oxidized compounds, the anaerobic reactor's oxidation-reduction potential (ORP) would have been very high compared to the control unit, making fermentation reactions impossible. Moreover, the substrate would have been removed using nitrate as the electron acceptor, making it unavailable to the polyphosphate bacteria. Thus, the continuous unit would have selected facultative bacteria rather than polyphosphate bacteria, and the compared mechanisms of BOD removal in the separate units would have been very different, though both would have been very successful.

B. Paper No. C-7: "The Influence of Extended Anaerobic Retention Time on the Performance of Phoredox Nutrient Removal Plants" by A. Gerber and C. T. Winter (South Africa)

This paper presented a laboratory investigation of the effect that varying the anaerobic unit detention time would have on the performance of three-stage Phoredox (modified Bardenpho) nutrient removal systems. Specifically, the experimental design varied the anaerobic hydraulic residence time from six to 24 hours, at six-hour intervals, and measured the changes in nitrification, denitrification, and phosphorus release and subsequent uptake, as well as COD removal. The operating sludge age was 20 days and the unaerated volume fractions varied from 60.0% to 77.8%.

Good phosphorus removal was obtained with a six-hour anaerobic detention time, but an increase to 12 hours improved it by 66%. Increases beyond 12 hours resulted in little or no further improvement. There were no observable detrimental effects on nitrification with the increased anaerobic times, signifying that the nitrification capacity of the system did not decrease, nor did the effluent TKN increase. The denitrification rates increased by 40% with an increase of the anaerobic detention time from six to 12 hours, but no further improvement was observed. There were no detrimental effects to COD removed.

The authors noted that there was no significant relationship between phosphate uptake or release and calcium concentrations in the units, thus establishing that removal was biological, not chemical. However, there was a good correlation between phosphate uptake and release and potassium and magnesium uptake and release, which is substantiation that the removal was biological. Filamentous bulking was not observed and the typical SVI range noted was 50 to 60 mg/L.

It was concluded that there were no detrimental effects when the detention time of the anaerobic unit was increased to as much as 24 hours, but improvements in both phosphorus and nitrogen removal rates were observed when the residence time was increased from six to 12 hours. The authors also observed that excellent phosphorus removal was obtained in spite of average influent COD/TKN ratios that ranged between nine and 10, which is below the requisite ratio for good performance reported by Ekama et al. (1983). This supports the author's contention that longer anaerobic detention times can be used to overcome the instability that can be caused by the introduction of nitrates into the anaerobic unit by sludge recycle.

C. Paper No. C-8: "Location of Phosphorus in Activated Sludge and Function of Intracellular Polyphosphates in Biological Phosphorus Removal Process" by T. Mino, T. Kawakami, and T. Matsuo (Japan)

The authors presented a method for the fractionation of intracellular forms of phosphorus, and used it to study the relative amounts of the phosphorus forms in activated sludge cells taken from three conventionally-operated plants and three plants operated for enhanced phosphorus removal. For the enhanced phosphorus removal plants, the flow scheme used was a simple anaerobic-aerobic system similar to that marketed in the U.S.A. by Air Products as the A/O Process. Each anaerobic-aerobic plant was paired with a conventionally-operated plant wherein each pair treated the same wastewater. After the cellular phosphorus compositions were compared, batch studies, using ^{32}P-labelled orthophosphates as tracers and sludges from the anaerobic-aerobic systems, were performed to elucidate the biological purpose of intracellular high molecular weight polyphosphates and of low molecular weight polyphosphate accumulation.

The results of the experiments generally confirmed the mechanisms of enhanced phosphorus removal proposed by Buchan (1982) and by Marais and co-workers at the University of Cape Town. It was shown that high molecular weight polyphosphates did not accumulate in any of the sludges to levels significantly greater than 2%, and they were used for cellular synthesis. On the other hand, the low molecular weight polyphosphates accumulated to produce phosphorus contents as high as 7% in the anaerobic-aerobic sludges (with no accumulation in the conventional plant sludges), and it was concluded that they serve as an energy source under anaerobic conditions for the uptake of organic substrates. Further, the results suggested that high molecular weight phosphorus was utilized only under aerobic conditions, but this might be an artifact of the flow schemes used.

The experimental results appear to be consistent with developed theory and with good experimental techniques, but insufficient information was given for a thorough evaluation. For example, no operating sludge ages or mixed liquor suspended solids (MLSS) concentrations were given for any of the systems. Also, no anoxic zone was designated by the authors for the enhanced phosphorus removal scheme, yet they gave no indication of what was done, if anything, to avoid nitrification. Basically, they had two choices. They could have operated at such a low sludge age that no nitrification occurred, or they could have suppressed nitrification by chemical addition. If nitrification did occur, the first chamber in the anaerobic tank must have served as an anoxic unit for denitrification. Otherwise, the enhanced phosphorus removal mechanisms would never have developed. It is actually critical that this information be known before the results can be fully interpreted for comparison with the principles developed by Ekama, et al. (1983).

The discusser, Brodisch (South Africa), suggested that the fractionation technique used made it difficult to distinguish between high and low molecular weight polyphosphates. She recommended a different method for nucleic phosphorus measurement and reported that she found twice as much nucleic phosphorus as the authors reported. Apparently Brodisch (South Africa) had analyzed pure cultures, and Mino (Japan) replied that this does not represent activated sludge conditions where only the average of the microbial mixture can be measured, rather than the extremes of individual species. He also stated that he recognized the limitations of the fractionation method, but believed it was adequate for the purposes of his experiments.

D. Paper No. C-9: "Modeling Phosphate Sludge Production" by R. G. Veldkamp (The Netherlands)

Veldkamp (The Netherlands) performed a three-factorial bench-scale experiment to quantify the mass and volume of sludge produced during chemical precipitation of phosphorus from wastewater. The three variables were chemical dosing level, phosphorus concentration, and pH. Seven chemical to phosphorus mole ratios, three phosphorus concentrations (ranging from 5 to 20 mg/L), and two values of pH (6.5 and 7.5) were used. The addition of both iron and aluminum salts was studied.

The results followed known relationships. Sludge production increased directly as both the initial phosphorus concentration and the chemical/phosphorus mole ratio increased. The author showed that linear relationships exist for sludge production per unit initial phosphorus present and the chemical dose to phosphorus ratio. Regression equations were found for these relationships. The pH effect was found to be negligible, which is not surprising considering the near neutral values chosen for the experiments. Iron addition produced more sludge than alum addition, but the iron flocs had better settling properties.

The author developed a regression model as well as a deterministic model and compared them. Development of the regression model showed that only the chemical dose/phosphorus ratio and the initial phosphorus concentration need be included in the resulting equation. In the deterministic model, the phosphorus removed was used instead of the initial phosphorus concentration. Theoretically, the results of the two equations should have been the same but they were not. The deterministic model predicted less sludge than was actually produced. The author suggested that the model should take into account some crystalline water instead of just the iron-phosphorus precipitates. His analysis indicated that two moles of water accompany each mole of $AlPO_4$ and slightly more water accompanies each mole of $FePO_4$.

The results of this paper are interesting and the goal of predicting sludge production is a good one, but the study was too limited, particularly in terms of scale and pH range, to produce usable design information. It was also clear that the deterministic model needs additional terms and/or modification before it can be accepted with confidence. The discusser, Gerber (South Africa), suggested additional factors that should be investigated for significance including pH, ionic strength, surface colloid characteristics, and the suspended solids concentration of the wastewater. Gujer (Switzerland) noted that biological factors should also be included.

E. Paper No. C-10: "Phosphorus Removal from Wastewater by Crystallization Method" by I. Joko (Japan)

This was the first of two papers presented on a novel approach to phosphorus removal. The author used an upflow fixed-bed whereas Paper No. C-11, authored by van Dijk and Braakensiek (The Netherlands) reported on a fluidized-bed investigation of the same mechanisms. (See first paper in the next session report.) Essentially, the method depends on the presence of seed crystals to catalyze precipitation of phosphorus and calcium in the metastable zone of calcium phosphate precipitation. The principal advantage of the approach is that no sludge is produced. Both batch and column laboratory experiments were performed and a 50 m^3/d pilot plant was operated.

The basic principle of reactor design was that nucleation of apatite occurs when soluble inorganic orthophosphate in wastewater comes into contact with phosphate rock. A series of batch laboratory experiments were conducted to determine the benefits of using a seed, whether any advantage could be gained by adding calcium to the wastewater, and if alkalinity increases caused detrimental effects. The experiments showed that seed addition was essential for phosphorus removal, that the performance of a column could be greatly prolonged by calcium addition and that increases in alkalinity reduced phosphorus removal efficiencies in batch tests, but not during continuous-flow column operation. Apparently, alkalinity effects were masked by pH effects in the column study.

Pilot-plant operation for a period of six months established the feasibility of the process. The pH of the wastewater was raised to nine by the addition of 70 mg/L of lime. The average influent concentration of 4 mg/L of phosphorus was always reduced to less than 1 mg/L in the effluent. Sludge production was practically negligible. The author reported that three full-scale and three pilot-scale facilities were operating in Japan at the time of the conference.

During the discussion period the author stated that the seed crystals in the experimental unit had been in use for 3.5 years without regeneration or replacement. He also noted that the bed had to be backwashed (fluidized) daily to remove trapped suspended solids. In response to a question from van Dijk (The Netherlands), Joko (Japan), stated that seed grain cementation is a problem and that much control must be exercised to avoid it. It is on this account that the use of fluidized beds and seeds other than phosphate rock is being investigated. van Dijk (The Netherlands) stated that the fluidized system could be operated with silica sand instead of phosphate rock.

Discusser Wiechers (South Africa) recognized the advantage of no sludge production, but noted that lime addition increased both the pH and the hardness, which was a disadvantage. He suggested that an economic comparison should be made between lime addition and aluminum or iron salts addition. Wiechers (South Africa) also noted that the ability to completely suppress nucleation and precipitation in the bulk liquid was central to the success of the crystallization process, but the experimental procedures used to obtain the critical supersaturation curves given in the paper were not reported. He felt that the data could have been more usefully and concisely presented in terms of critical supersaturation concentration products and apparent solubility products.

Gujer (Switzerland) asked if the process could produce a total phosphorus concentration of 0.2 mg/L or less. Joko (Japan) replied that the fixed bed could not be relied on to obtain that concentration because efficiency drops as temperature decreases.

4. CRITIQUE OF SESSION

The first three papers of this session were designed to investigate or advance the mechanisms of enhanced biological phosphorus removal as developed and reported by Marais (South Africa) and his co-workers at the University of Cape Town (see Ekama *et al.*, 1983) and Buchan (South Africa, 1982). The data presented by Fukase *et al.* (Japan) in Paper No. C-6 is too inconsistent to be accepted. During the discussion he stated that nitrification did occur in Unit B, Phase 3, but he didn't believe the amount recycled was significant. The writer's experience, and that of Marais (South Africa), is that it was very significant and would have completely changed the dominant biochemical mechanisms in that unit. Therefore, his postulates, which were at variance with those of both Marais (South Africa) and Buchan (South Africa) should be questioned. By contrast, the work by Gerber and Winter (South Africa), as reported in Paper No. C-7, was well-done and adequately reported. Their results advance rather than contradict the reports of Marais and his co-workers. Marais (South Africa) has reported that the return of substantial amounts of nitrates to the anaerobic unit will cause failure of the enhanced biological phosphorus removal system. Gerber and Winter (South Africa) have shown that, while that might be true when the anaerobic detention time is short, it can be overcome by using long anaerobic detention times. The writer's interpretation is that the state of the anaerobic reactor is reflected by the prevailing oxidation-reduction potential (ORP). When the nitrate mass is high compared with the anaerobic volume, the ORP increases and the poly-P organism reactions become non-competitive. In contrast, when the same nitrate mass enters a large anaerobic reactor, the nitrates are reduced without signficantly changing the ORP, and the poly-P reactions dominate. While the results of Gerber and Winter (South Africa) are interesting, it is unlikely that anaerobic detention times of 12 hours or more will ever be utilized. Other researchers such as Barnard (South Africa) and Oldham (Canada) are currently developing procedures for the acceleration of poly-P reactions in the anaerobic unit at Kelowna, British Columbia, and their approach seems likely to prevail.

The results of Paper No. C-8 were consistent with the poly-P mechanisms reported by Buchan (1982) and appeared to be of good quality, but the experimental procedures were inadequately reported.

The work of Veldkamp (Paper No. C-9) had a worthy objective and the quality of the experimental work was good, but the results fell short of accomplishing the goals. The work needs to be extended before information adequate for design purposes will be obtained.

Joko (Japan) presented a novel and interesting process for the removal of phosphorus in Paper No. C-10, but his results were eclipsed by those in Paper No. C-11, reported by van Dijk (The Netherlands). It seems fairly certain that practical nucleation process designs will utilize fluidized beds, and it is probable that silica sand or some material other than phosphate rock will be used as the granular seed.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

All of the papers presented during this session have material of considerable significance to U.S.A. water pollution control efforts. Wastewater phosphorus removal needs to be implemented as a conventional practice in many parts of the U.S.A., particularly the East Coast, and economical methods for accomplishing nutrient removal are needed. Research in the U.S.A. has practically ignored biological phosphorus removal for the past ten years and a considerable "knowledge gap" exists between the U.S.A. and South Africa, in particular, and Japan and Europe to a lesser degree. Yet, at present, the technology is being introduced and implemented in the U.S.A. at several locations. The danger is that the systems will not be properly designed for U.S.A. conditions and widespread failure will occur needlessly. The three papers presented on enhanced biological phosphorus removal all contain data that show the systems are feasible and can be made to work reliably. Research and development of economical biological nutrient removal systems needs to progress as rapidly as possible.

The crystallization process for phosphorus removal appears to have considerable promise for utilization in the U.S.A. It was noted by van Dijk (The Netherlands) that addition of a fluidized bed system will add about 25% to the cost of a conventional wastewater treatment plant. It is likely that this cost increase will be acceptable at many locations for the removal of phosphorus. This process deserves further study and development.

1. SESSION

A. Day: Tuesday, September 18, 1984
Location: Hall 1
Time: 2:00-5:25 p.m.

B. Theme of Session: Phosphorus Removal; Anaerobic Treatment; Oxidation and Formation of Sulfide

2. REVIEWER

A. Name: Joseph F. Malina, Jr.

B. Position and Affiliation: C. W. Cook, Professor of Environmental Engineering and Chairman of the Civil Engineering Department, The University of Texas, Austin, Texas (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

A. Paper No. C-11: "Phosphate Removal by Crystallization in a Fluidized Bed" by J. C. van Dijk and H. Braakensiek (The Netherlands)

Phosphorus removal in pilot-plant studies using a fluidized bed reactor was discussed by van Dijk (The Netherlands). Caustic soda or lime was added to biologically-treated sewage to raise the pH and provide calcium, in the case of soft waters. Crystallization of calcium phosphate on silica sand grains (0.1-0.3 mm) resulted in the formation of pellets (0.6-2 mm) which were removed periodically from the bottom of the reactor. The main advantage of the process is the production of a small amount of hard, durable and reusable calcium phosphate pellets, instead of large volumes of sludge which are produced when lime, alum or iron salts are used to precipitate phosphate.

The design of the inlet ports to insure intense mixing is important since local supersaturation of calcium phosphate results in nucleation of calcium phosphate in the water instead of precipitation on the pellet surface. A similar phenomenon was reported earlier by Yoko (Japan, Paper No. C-10).

Effluent orthophosphate concentrations were less than 1 mg/L soluble, 0.1 mg/L organic (1.0 mg/L organic for trickling filter effluents) and 0.44 mg/L filterable when 0.25 mm sand and proper nozzle design were used. No significant concentration of calcium was detected. The estimated cost for a system treating sewage from 10,000 population equivalents is approximately $3 (U.S.A.)/pop. equiv.-y.

Witter (South Africa) estimated that phosphorus removal would add 20-30% to the cost of the existing biological treatment plant. The results reported in this paper and in Paper No. C-10 (fixed-bed reactor) are very similar, and the conclusions drawn are complementary. In a fluidized-bed reactor suspended solids are discharged with the effluent. However, in a fixed-bed reactor the suspended solids and associated phosphates are trapped in the bed.

B. Paper No. C-12: "Batch Anaerobic Methanogenesis of Phenolic Coal Conversion Wastewater" by P. M. Fedorak and S. E. Hrudey (Canada)

Fedorak (Canada) discussed the use of batch anaerobic systems to screen possible inhibitory or toxic effects of coal gasification wastewater which contained a high concentration of phenolics (phenol, o-, m- and p-cresols) and low cyanide. This wastewater was treatable anaerobically at a dilution of 6% by volume. Inhibition of methane production was observed at a wastewater dilution of 8%; however, phenol, p-cresol and m-cresol were completely removed. The inhibition was associated with an ether-extractable fraction of the wastewater.

Pohland (U.S.A.) pointed out that dilution detracts from economic advantages gained by reusing the methane produced since the required capacity, capital cost and energy requirements are increased. A fluidized-bed reactor with granular activated carbon media offers some promise, since carbon adsorbs some of the potentially inhibitory compounds and provides a growth surface and a greater acclimation opportunity for the attached anaerobic biomass. It is essential that efforts continue to identify the inhibitory substances which, in synergistic or antagonistic combinations, are important to anaerobic treatment. Certain targeted compounds can be used as surrogate indicators of inhibition or breakthrough of the inhibitory materials. Fedorak (Canada) pointed out that m-cresol is an indicator of inhibition, since it appears in the effluent when the anaerobic system is upset; however, this advantage is lost, if activated carbon is used since the m-cresol would be adsorbed onto the carbon.

C. Paper No. C-13: "Thermophilic Anaerobic Contact Digestion of Palm Oil Mill Effluent" by A. Ibrahim, B. G. Yeoh, S. C. Cheah, A. N. Ma, S. Ahmed, T. Y. Chew, R. Raj and M. J. A. Wahid (Malaysia)

Ibrahim (Malaysia) discussed thermophilic anaerobic treatment of palm oil wastes with recovery of biogas using a pilot anaerobic contact system with a final clarifier. The waste contained high concentrations of organics (BOD and COD) and suspended solids. Approximately 94% of the BOD was removed at maximum organic loadings of 3.11 kg BOD/m^3-d at 45^{o}C (hydraulic detention times of 5.9 to 10 days) and 3.44 kg BOD/m^3-d at 50^{o}C (hydraulic detention times of 4.7 to 8.3 days). The methane production was 0.60 and 0.71 m^3 methane/kg BOD-d, respectively, at 45 and 50^{o}C. Excessive amounts of foam formed at high organic loadings and mixed liquor was carried over into the effluent causing a loss of biomass. The organic loading was limited by the foaming. Control of sludge age was not possible, and solids were wasted only when there were operational problems.

Microbiological analyses of the thermophilic anaerobic liquor indicated a sulfate-reducing bacterial population of 10-100/mL at 50^{o}C. This population was approximately 1,000 times less than that reported for mesophilic conditions. The sulfate-reducing bacterial population decreased even more at 55^{o}C. The energetics of the system dictates the total reduction of sulfate before methane production. Methanogenic bacteria require sulfide and metals for efficient operation. However, sulfide tends to react with metals forming insoluble precipitates.

The rate-limiting step is either hydrolysis, acid formation or the conversion of proprionate, rather than conversion to methane. Controlling foam in the anaerobic reactor is crucial to the performance of the system. Foam was a serious concern to the operators of thirty municipal sludge digesters in the U.S.A. which were surveyed by Speece (U.S.A.). The causes of foam generation and the compositions of foam in anaerobic digesters and contact systems need to be understood more fully since foaming problems seriously limit the loadings to the anaerobic systems.

Speece (U.S.A.) emphasized the importance of the bioavailability (available for use by the organisms) of iron and other metals to the performance of methanogens. The total metal concentration does not indicate bioavailability.

D. Paper No. C-14: "Oxidation of Sulfide and Thiosulfate and Storage of Sulfur Granules in Thiothrix from Activated Sludge" by P. H. Nielsen (Denmark)

Nielsen (Denmark) elaborated the physiology of the filamentous bacteria Thiothrix and Type 021N and, using photomicrographs, clearly illustrated the formation of filaments which were several millimeters long and contained sulfur granules. In the presence of dissolved oxygen, Type 021N was able to oxidize sulfides and thiosulfate forming intracellular sulfur granules. Type 021N has been associated with sludge bulking; however, the significance of sulfide and thiosulfate oxidation to sludge bulking requires additional study. Nielsen (Denmark) reported the prevalence of Thiothrix including Type 021N in all of 14 treatment plants from which he collected samples; however, bulking was not observed in six plants. Thiothrix caused bulking in only four of the eight plants where they were the dominant species. It appears, therefore, that the presence of Thiothrix itself does not necessarily produce a bulking sludge.

Type 021N and Thiothrix have been implicated in bulking when the causative agent was any one of a number of factors. Sludge bulking has been attributed to low dissolved oxygen in the mixed liquor, low pH, nutrient deficiency (most probably nitrogen), low organic loading, sludge age, and the septicity of the wastewater. Jenkins (U.S.A.) summarized many of these factors in a recently published paper. Identification of a specific dominant organism does not definitively identify the particular cause of bulking sludge. A thorough understanding of the mixed population is needed before effective pure culture studies can be designed. Bulking is related to environmental parameters. The organisms present in the system are the manifestation of those conditions favorable to growth. Consequently, the environmental conditions that are favorable to each species should be identified and these parameters monitored in prototypical systems.

E. Paper No. C-15: "Kinetic Studies of the Microbiological Conversion of Sulphate to Hydrogen Sulphide and Their Relevance to Sulphide Generation within Sewers" by G. A. Holder, G. Vaughan and W. Drew (Australia)

Holder (Australia) presented an empirical model and discussed the results of a laboratory study using slime grown on tubes flowing full. The results of the study indicated that, at high concentrations of sulfate (1,000 to 2,000 mg/L), sulfate reduction was linear with distance and the rate of sulfate reduction was 30 mg/h-cm^{3} of slime and approximated zero-order. However, at sulfate concentrations less than 500 mg/L, the rate approximated a half-order or first-order reaction and sulfate reduction was non-linear with distance.

Typical sulfate concentrations in sewers are much lower and the BOD higher than the concentrations used in this study. Although much attention has been given to sulfate-reducing bacteria in the slime in sewers, the suspended solids and the biomass in the sewage also contribute to the reduction of sulfate. These solids as well as temperature, velocity, and possibly oxidation reduction potential should be included in the model.

4. CRITIQUE OF SESSION

The papers in this session varied in subject matter among three unrelated areas and were of varied quality and application. Data presented in Paper No. C-11 indicated soluble phosphate removal to levels less than 1 mg/L by crystallization of calcium phosphate on sand grains in a fluidized-bed reactor. These data confirmed results that were reported in Paper No. C-10 for a fixed-bed reactor.

Paper Nos. C-12 and C-13 focused on anaerobic treatment. Paper No. C-12 dealt with a screening technique for evaluating inhibition caused by coal gasification wastewater. Phenol, m-cresol and p-cresol were completely removed at an 8% by volume dilution of the wastewater. Inhibiton was associated with an ether-extractable component. This screening protocol can be used to identify the inhibitory effect of various compounds on anaerobic systems. Paper No. C-13 was more applied and showed the applicability of the anaerobic contact process for the treatment of high strength industrial wastewaters. Sulfur-reducing bacteria were fewer in number under thermophilic conditions than those reported for mesophilic systems. One of the major factors limiting the application of higher organic loadings to the anaerobic contact process and to anaerobic sludge digesters is the generation of foam which causes operational problems.

Papers Nos. C-14 and C-15 were very much different, although each paper addressed problems with sulfur. Paper No. C-14 focused on the microbiology and physiology of Thiothrix and Type 021N, which have been implicated in activated sludge bulking. The role of sulfide and thiosulfate oxidation and deposition of sulfur in these filamentous organisms in activated sludge bulking requires additional research. Environmental and operational parameters which effect sludge bulking and the dominance of Thiothrix and Type 021N in activated sludge systems also were discussed. Paper No. C-15 dealt with an empirical model of the conversion of sulfate to hydrogen sulfide in sewers.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The packed-bed and fluidized-bed reactors for removal of phosphorus from secondary treatment plant effluents by crystallizaiton into pellets provides an alternative to using chemical precipitation techniques and generation of large volumes of difficult to dewater sludges.

Information on the application of an assay technique for identification of inhibitory and/or toxic components of complex wastewater (coal gasification) can be modified to improve applicability to other industrial wastes which may be biodegradable anaerobically (e.g., leachate from hazardous waste sites). The effectiveness of anaerobic treatment of complex wastes in fluidized granular activated carbon bed reactors needs to be developed in more detail. Other information presented on anaerobic treatment highlighted problems observed in the U.S.A. Additional research into factors affecting anaerobic processes is essential to fully utilize the capabilities of these systems to efficiently treat highly concentrated industrial wastes and sludges. Specific areas include: a more detailed understanding of the bioavailability of metals in anaerobic systems; and evaluation of the composition of foams in anaerobic contact processes and sludge digesters and the factors effecting the generation and control of foam which currently limit the applicaiton of these systems at high organic loadings.

Sulfide and thiosulfate oxidation by *Thiothrix* and Type 021N and the effects on activated sludge bulking are interesting; however, there are many other environmental and operational factors that affect sludge bulking. A more thorough understanding of the mixed population of organisms and the favorable environmental conditions for each species to form filaments is needed before effective pure culture studies can be designed.

1. **SESSION**

   A. Day: Wednesday, September 19, 1984
   Location: Hall 1
   Time: 9:00 a.m. - 12:25 p.m.

   B. Theme of Session: Activated Sludge

2. **REVIEWER**

   A. Name: Bruce E. Rittman

   B. Position and Affiliation: Associate Professor of Environmental Engineering, University of Illinois, Urbana, Illinois (U.S.A.)

3. **DESCRIPTION OF SESSION PAPERS**

   A. Paper No. C-16: "Mixing and Detention Time Distribution in Activated Sludge Tanks" by H. Bode and F. Seyfried (Federal Republic of Germany)

This paper presented a method by which the detention time and mixing regime of an activated sludge aeration tank can be estimated without disturbing the normal operation of the process. The major new development was a technique for taking into account the recycle of return sludge which contains tracer material. The technique requires measurement of the tracer concentration in the return sludge or in a parallel basin having a common clarifier. Application of the technique to a full-scale oxidation ditch showed a substantial degree of short-circuiting caused by poor lateral mixing in the ditch.

Discussions focused on the use of more sophisticated methods for data analysis and the applicability of the results. One major criticism was that knowing macromixing phenomena is not very useful because the important reactions occur very quickly on a microscale. Another criticism was that the reactor plus clarifier is the proper system for which to determine detention time. However, the technique is useful for uncovering problems of gross short-circuiting which might adversely affect effluent quality.

B. Paper No. C-17: "Influence of Macromixing on Organic Carbon Uptake and Solids Production by Aerobic Suspended Biomass" by S. Elmaleh, T. I. Yoon, and A. Grasmick (France)

The authors presented results from once-through biological systems fed a complex organic substrate, beef extract. One system was a complete mix reactor, while the second system was divided into four or eight compartments in series. In terms of soluble effluent TOC, one-, four-, and eight-stage systems give nearly equal performance which suggests that TOC removal was a zero-order process. However, a compartment-by-compartment analysis of the substrate utilization rate gave a first-order function of soluble TOC concentration. The apparent contradiction was unresolvable because the biomass concentrations in the compartmentalized systems were much lower than in the one-stage system; the authors explained the low biomass concentrations with a very large respiration coefficient (up to $0.34\ h^{-1}$).

This paper was praised by several discussers because it showed that microorganisms grown in completely mixed systems are very different from those grown in a compartmentalized system. However, the applicability of the results to practice are seriously circumscribed by five weaknesses. First, the growth rates used, 0.11 to $0.25\ d^{-1}$ in the one-stage system, were very high and at least an order of magnitude greater than used in practice. Second, the compartmentalized systems had widely varying specific growth rates (from near the maximum rate to negative) which never occur in a recycle system. Third, the authors did not account for wall growth, which might have been very significant in the compartmentalized systems. Fourth, the use of TOC as a substrate measure allowed for different degrees of oxidation even though the TOC concentration was the same. Finally, the determined respiration coefficients for the compartmentalized system were at least an order of magnitude greater than normally observed; such a wide discrepancy suggests experimental error.

C. Paper No. C-18: "An Equalization Control Strategy for Activated Sludge Process Control" by P. L. Dold, H. O. Buhr, and G. v. R. Marais (South Africa)

Dold (South Africa) presented a strategy useful for implementing in-line equalization when a microprocessor is available. The strategy controls the outflow from an in-line equalization tank by minimizing an object function that takes into account the flow rate, mass load, tank capacity, and the rate of change of flow rate. To fully implement the control strategy, the user must have the following: (a) a means to measure influent flow rate/concentration; (b) a means to measure liquid volume in the equalization tank; (c) a means to control the outflow rate; and, (d) a historical record of flows and concentrations during the cycle.

The strategy was demonstrated with records for a municipal sewage treatment plant in South Africa. The simulation demonstrated that flow and load could be equalized for the normal diurnal variations to the plant. Considerable discussion was related to how well this strategy would perform for non-periodic events such as peak flows during rain events. Apparently the strategy functions satisfactorily if the peak non-periodic flow is only fractionally greater than the normal flows. When non-periodic flows are large, plant bypassing is needed.

The situation for which the equalization strategy was developed is to protect the multiple-stage processes used for nutrient removal in South Africa. The author indicated that this strategy is not very useful for conventional activated-sludge processes where adsorption of colloidal organic material is the dominant removal mechanism. Since work on the actual effects of load variations was minimal, the author's assertions about the utility of this strategy cannot be evaluated.

D. Paper No. C-19: "The A-B Process: A Novel Two Stage Wastewater Treatment System" by A. I. Versprille, B. Zuurveen and Th. Stein (The Netherlands)

The paper was a rather general overview of the A-B Process which the authors' firm is marketing. The A-B Process is a two-stage activated sludge process: the first (A) stage is high rate aeration (about 10 kg BOD/m^3-d) followed by settling, while the second (B) stage is low rate aeration and settling. There is no recycle from the B stage to the A stage. Results showed very good effluent quality in terms of BOD (4-7 mg/L) and sludge volume index (SVI) (less than 130 mL/g). On the other hand, the paper presented very little operating data which made a detailed analysis of the process impossible.

The authors presented an economic analysis which indicated large savings in capital and operating costs. However, Grau (Czechoslovakia) disputed these findings and said that his analysis showed no savings in tank volume or cost. It seems likely that the authors did not compare the A-B Process to the best alternative.

Discussions about the mechanisms of removal in the A stage disputed the authors' claim that bio-oxidation was important. The very high waste-sludge concentrations from the A stage (roughly 2%), as well as a very low O_2 utilization (c. 0.1 kg O_2/kg BOD), support the discussers' opinions that the A stage mainly allowed sedimentation and adsorption of influent suspended solids. The results of this paper are insufficient to determine whether or not aeration in the A stage offered significant advantages in comparison to normal primary sedimentation. Applicability to wastewaters not having a large fraction of suspended BOD also was not shown.

E. Paper No. C-20: "Flexible Modelling of the Activated Sludge System--Theoretical and Practical Aspects" by M. S. Sheffer (Israel), M. Hiraoka (Japan), and K. Tsumura (Japan)

The product of this paper is a "flexible model" of the activated sludge process. The model includes suspended and dissolved organic substrates in the liquid phase, suspended and dissolved organic substrates adsorbed to biological solids, active biological solids, and inert biological solids. The model is flexible in that the various components can be lumped to form several levels of more simplified models. Simulations with the various modeling levels showed that steady-state biomass concentrations were hardly affected by model choice, but that effluent concentration depended on the model level. The authors also presented a scheme by which kinetic parameters could be updated in response to system performance.

Discussions raised three problems for use of the model. First, not all mechanisms or compartments are included; Eckenfelder (U.S.A.) stressed that biocoagulation was omitted. Second, the need to regularly update parameters makes predictions of the effects of process control strategies doubtful. Third, the value of real-time process control is unproven especially because of the long time constant for activated sludge and the few options available to be adjusted.

4. CRITIQUE OF SESSION

The five papers in the activated sludge session were of highly different subjects and approaches. Although each paper and presentation was of generally good quality, their usefulness to biological process design and operation is limited. Paper No. C-16 presented a simple technique to assess the mixing characteristics of an aeration basin that receives recycle. Except for detecting gross short-circuiting, currently little use can be made of the mixing results. Paper No. C-17 showed that bacteria grown in compartmentalized reactors can be markedly different from those grown in completely-mixed reactors. Although recognizing that differences can occur is valuable, the shortcomings of the study (high and variable specific growth rates and possible experimental errors) makes its direct application impossible. Paper No. C-18 presented a simple and apparently successful technique to equalize loads. This paper could be very valuable in the future if it is shown that load fluctuations cause significant deterioration in process performance. Paper No. C-19 was an overview designed to introduce the A-B Process. Because of a lack of process data, the paper does not allow a critical evaluation of the process. Paper No. C-20 presented a model that could be used for real-time control of activated sludge. The value of the paper is mitigated by uncertainty about mechanisms and a lack of process sensitivity to short-term adjustments.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The session on activated sludge pointed to at least three areas in which research activities are needed and should yield benefits. The first area is better elucidation of the fundamental mechanisms of substrate removal and biomass growth, especially when the wastewater contains colloidal BOD. Second, U.S.A. research and practice needs to be more cognizant of issues more common in other countries; a good example is multiple-compartment reactors. Third, well conceived research is needed to assess the impact of load variations on the performance of a variety of biological processes.

1. SESSION

   A. Day: Wednesday, September 19, 1984
   Location: Hall 1
   Time: 2:00-5:25 p.m.

   B. Theme of Session: Kinetics and Aeration in Aerobic Treatment

2. REVIEWER

   A. Name: James E. Alleman

   B. Position and Affiliation: Associate Professor, Purdue University, West Lafayette, Indiana (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-21: "Determination of Kinetic Constants of Activated Sludge Microorganisms" by J. S. Cech, J. Chudoba, and P. Grau (Czechoslovakia)

Two complementary topics were addressed within this paper including: the use of respirometric analysis for determining activated sludge kinetic constants; and, a comparison of the kinetic behavior exhibited by microorganisms cultivated under selector-type and completely-mixed reactor environments. After reviewing the normal mechanisms for measuring the half-reaction coefficient, K_s, and specific substrate utilization rate, r_s (i.e., based on either batch, chemostat, or infinite-dilution testing), the authors' simplified batch respiration assay was described and demonstrated using a variety of substrate materials.

Although subsequent discussion of this procedure was generally positive, several areas of concern were raised. The analogy by Grady (U.S.A.) of the test as a "snapshot" underscored a fundamental uncertainty regarding the correct strategy for evaluating an inherently dynamic mixed-culture. In particular, the premise of representative biomass behavior was questioned due to the required starvation of the cells during a sixty-minute pre-aeration step. Furthermore, Grady's (U.S.A.) reported experience with the collection and interpretation of respiration data suggested that useful results would require several replicate assays.

The described mathematical derivation of r_s was based on a known substrate addition rather than actual substrate tension. This simplification, therefore, neglected progressive substrate depletion during the test. Related comments by Saunders (U.S.A.) also focused on the consideration of mass transfer characteristics and intracellular substrate storage. Overall, these latter factors probably contributed to the inflated K_s values consistently observed by the authors with their respiration-based determination. The agreement observed between the 'respiration-based' and 'infinite dilution' results derived from parallel tests did, however, provide a basic validation of the utility of the proposed technique.

As for the comparison of data obtained with biomass generated under selector-type and completely-mixed reactor conditions, these results largely supported and reinforced Chudoba's (Czechoslovakia) earlier concept of selective control over a microbial population. Biomass cultivated with the selector-type reactor uniformly exhibited higher maximal specific substrate removal rates.

B. Paper No. C-22: "The Potential Use of Enzymes for Removal of Aromatic Compounds from Water" by S. W. Maloney, J. Manem, J. Mallevialle and F. Fiessinger (France)

Enzyme catalysis of oxidative coupling reactions was examined as a prospective removal mechanism for industrially-generated aromatic hydrocarbons. Various levels of peroxide and horseradish peroxidase were applied to a representative set of chlorinated phenolics, including mono- (2-CP), di- (2,4-DCP), and pentachlorophenol (PCP), at concentrations in the ppb to ppm range.

Initial experimentation of PCP was apparently unsuccessful with a maximal removal of 20% to 30%. Subsequent removals attained with the horseradish peroxidase/peroxide treatment of 2-CP and 2,4-DCP forms were, however, as high as 95%. High performance liquid chromatography analysis of the reaction products indicated that byproducts were produced only with the dichlorophenol material. Whereas the paper identified these latter residues as undefined polar and non-polar compounds, Maloney's (France) updated description of these byproducts proved quite alarming. The non-polar fraction, accounting for one-third of the initial 2,4-DCP mass, was characterized as having dioxin-type linkages.

In turn, the products of this treatment process might well be worse than the initially targeted pollutant. Although Maloney (France) expressed confidence that horseradish was an acceptable culinary substance (i.e., in response to an inquiry by Wukasch, U.S.A.), a warning was given against the industrial discharge of substituted phenols due to the possibility of analogous natural reactions leading to similar dioxin-type toxins.

C. Paper No. C-23: "Development of Pollutant Specific Models for Toxic Organic Compounds in the Activated Sludge Process" by A. T. Watkin and W. W. Eckenfelder, Jr. (U.S.A.)

This paper developed the concept of applying pollutant specific Monod models with multi-substrate biodegradation in completely-mixed, recycle reactors. Three compounds were evaluated including: phenol, 2,4-dichlorophenol, and 2,4-dinitrophenol. A concurrent model for specific substrate biodegradation and volatilization was also developed and applied to two compounds: dinitrobenzene and carbon tetrachloride. Substrate adsorption, however, was excluded from these specific modeling strategies on the premise that these phenomena are poorly understood.

Discussion focused on omission of the adsorption pathway and on the difficulty of preparing and quantifying an all-encompassing model for specific toxins. Although the approach developed was considered a useful starting point, the author agreed that adsorption must be considered in order to facilitate a complete model.

Weber (U.S.A.) emphasized that the current state-of-the-art for modeling this behavior was considerably more advanced than the paper implied. As for the use of Monod models for biodegradation, it was emphasized that this practice neglects the occurrence of multi-substrate pathways and of cooxidation between primary and secondary substrate forms. The validity of a Monod-form model in the case of low concentration substrates was correspondingly questioned. Finally, Grady (U.S.A.) emphasized that the concept of a minimum substrate concentration, as stressed in the paper, was probably not applicable in this context of low toxic concentrations.

D. Paper No. C-24: "The Kinetic Analysis of BOD and Nitrogen Removal in an Oxidation Ditch" by Y. Terashima and M. Ishikawa (Japan)

The kinetic model presented by this paper encompassed simultaneous removals of organic carbon and nitrogen within an oxidation ditch. Monod-form kinetics associated with BOD_5 oxidation, nitrification, and denitrification were expanded to reflect the positive or negative effect of dissolved oxygen tension; the nitrification reaction was also modified according to alkalinity availability. The modeled oxidation ditch included five completely-mixed reactors in series with extensive internal recycle and tank-to-tank backmixing. Aeration and raw waste input took place in the first tank.

Steady-state computer simulations completed on this system at hydraulic retention times (HRT) of 12 to 30 hours indicated that alkalinity availability had a significant impact on nitrogen metabolism. The applied waste composition lacked sufficient alkalinity for complete nitrification such that optimal nitrification/ denitrification metabolism occurred between HRT values of 15 and 20 days.

Discussion focused solely on the relative utility and sophistication of the employed standard Monod model for organic carbon oxidation. Additional refinements were suggested according to an expected 'real-world' distribution of influent organics between soluble and particulate forms with biodegradable and non-biodegradable characteristics. Extending beyond this concern, however, it was apparent that the authors' 'concurrent' carbon and nitrogen removal model might have been tapped for insights other than the alkalinity factor. Specifically, this model could be used to explore a variety of design and operation strategies for single-sludge, looped reactor designs.

E. Paper No. C-25: "Steady State Measurement of Oxygenation Capacity" by K. de Korte and P. Smits (The Netherlands)

This paper described a steady-state procedure for measuring oxygenation capacity and reported on its full-scale application with completely-mixed, plug-flow, and looped-reactor activated sludge systems. The technique involved isolating a reactor for 12 hours to attain endogenous respiration followed by measurements of the in situ and saturation dissolved oxygen levels as well as the biomass respiration rate. The oxygenation capacity under process loading conditions was then extrapolated from this determination of the oxygen transfer rate under 'endogenous respiration' conditions.

Although this procedure does have practical merit, there are several potential problems and/or deficiencies which must be addressed. First, the practice of isolating a particular process reactor for 12 hours was acknowledged as a tenuous proposition for plants at or above their design flows. Secondly, the authors admitted that the oxygenation capacity calculation was extremely sensitive to inaccuracies in the ambient D.O. measurement (e.g., with a 0.2 mg/L difference causing 10% error). Third, a mid-depth correction for the saturation D.O. value in a diffused aeration system may not be proper. Finally, the authors neglected the possibility of a variance in the alpha coefficient upon reverting back to the process loading condition. Related changes in the composition of the wastewater may result in a substantial alteration of the attainable oxygen transfer capacity.

4. CRITIQUE OF SESSION

Paper Nos. C-21 and C-25 involved the measurement of mixed liquor respiration rates, although in different contexts. Paper No. C-21 introduced an expedient technique for determining kinetic constants which will undoubtedly promote future research along similar lines. In conjunction with its presented data, this paper provided several new insights on the metabolic behavior of 'fast' and 'slow' growing microorganisms cultivated in selector-type and completely-mixed reactors.

Paper No. C-22 dealt neither with kinetics nor aeration and was, therefore, misplaced within this session. Furthermore, the observed production of a dioxin-type byproduct warranted a serious concern about the future application of this proposed enzyme-catalysis treatment scheme.

Paper Nos. C-23 and C-24 both examined mathematical models for suspended-growth systems. Introduction of a pollutant specific modeling approach in Paper

No. C-23 certainly coincides with current interest in the fate of specific toxins within these biological systems. Discussion of this paper emphasized the necessity for additional research on the involved metabolic and physical-chemical pathways for low concentration hazardous wastes. Paper No. C-24 provided an interesting model of carbon and nitrogen metabolism within an oxidation ditch, but did not make full use of its research potential.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The value of Paper No. C-21 stems not only from its particular application of respiration analysis, but also from the results provided on two diverse microbial forms. Respirometric analysis of suspended-growth cultures represents a timely research topic and one which is currently being pursued by a number of U.S.A. investigators. Attention to the physiological characteristics of microorganisms maintained under 'fast' versus 'slow' growth reactor conditions has also been promoted based upon the desired capability of selectively controlling these characteristics. The modeling strategies carried by Paper Nos. C-23 and C-24 should also provide a useful starting point for future research on the metabolism of specific components within an activated sludge system including both conventional (i.e., organic carbon and nitrogen) and hazardous substrates.

1. SESSION

   A. Day: Thursday, September 20, 1984
   Location: Hall 1
   Time: 9:00 a.m. - 12:25 p.m.

   B. Theme of Session: Industrial Wastewater Treatment; Nitrification and Denitrification

2. REVIEWER

   A. Name: James W. Patterson

   B. Position and Affiliation: Professor and Chairman, Pritzker Department of Environmental Engineering, Illinois Institute of Technology, Chicago, Illinois (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-26: "Removal of Iron Cyanide from Gold Mill Effluents by Ion Exchange" by D. T. Vachon (Canada)

Vachon (Canada) described laboratory ion exchange studies on synthetic and actual gold mill effluents. The studies were performed using a strongly basic anion exchange resin (Rohm & Haas Amberlite IRA-958). The process was evaluated primarily with respect to removal of iron (ferri- and ferro-) cyanide complexes which are not effectively treated by more conventional cyanide treatment processes. Resin regeneration was by concentrated (10 to 15%) sodium chloride solution, thus operating the anion exchanger on the chloride cycle.

Although the process was somewhat effective in removing iron cyanide, it appeared to have several deficiencies. First, the resin capacity was observed to be quite variable, apparently being influenced by other constituents of the wastewaters tested. Both copper cyanide and zinc cyanide, also present in the wastewaters, competed for resin sites with the iron cyanide. Limited data presented in the paper suggested that zinc cyanide cannot be removed below an effluent zinc level of about 25 mg/L. Further, copper cyanide consistently broke through the resin column significantly before iron cyanide breakthrough, thereby reducing the effective on-line resin treatment capacity for iron cyanide. A further deficiency of the process involved resin regeneration. Sodium chloride regeneration yielded iron cyanide recoveries ranging from 40 to 100% efficiency. In multiple cycles of testing, the resin lost 25% of its capacity upon first regeneration and approximately 1% per cycle thereafter. Vachon (Canada) noted that pilot-scale studies would be required to verify and expand the laboratory performance data and to evalute the economics of the process. During general discussion, the author indicated that only one resin and one regenerant were tested. One member discusser suggested that sodium hydroxide might be a more effective regenerant than that utilized.

B. Paper No. C-27: "Total Effluent Treatment and Rinse Water Reclamation in a Semiconductor Device Manufacturing Facility" by P. S. Cartwright (U.S.A.)

This paper presented a case study of an extraordinarily expensive installation to treat and reclaim a semiconductor manufacturing rinsewater. Semiconductor rinsewaters must be extremely pure, and this imposed a requirement for a degree of treatment for reuse that would not normally occur for treatment for reuse in other categories of industry, nor indeed warrant recovery in a semiconductor facility unless constrained by very arid circumstances. Such circumstances did not apply at the geographical location of this facility.

Notable aspects of the installation include the fact that it only treats 75,600 L/d of a 272,160 L/d total rinsewater flow at an installed cost of U.S. $500,000. The excess rinsewater flow is discharged after conventional pretreatment to a municipal sewer. All components of the rinseweater recovery/recycle system were supplied by a single vendor. The components are: activated carbon; reverse osmosis; second-stage activated carbon; two-bed ion exchange demineralization; ultraviolet irradiation; and ultrafiltration.

C. Paper No. C-28: "Development of a New Process for Treating Uranium Mining Effluents" by P. M. Huck, W. B. Anderson, and R. C. Andrews (Canada)

This paper described a very innovative modification of the conventional precipitation process for treatment of radium-226. The process utilized a fluidized bed reactor (silica sand media) to precipitate mixed barium/radium sulfate. The resulting salt was granular and reported to be free-draining.

Results were presented for laboratory and field studies. Radium removal efficiencies exceeded 90% at contact time near 20 seconds. Field tests with time-varient influent radium concentrations and a fluidized-bed contact time of 18 seconds yielded a mean radium removal efficiency of 94% and a stable effluent radium concentration. The authors concluded that the percentage of removal efficiency is independent of influent concentration although, more precisely, effluent concentration should be independent of influent concentration since the process involves insolubility phenomena. In response to an inquiry from Matsui (Japan), the presenter indicated that the process performance was not sensitive to pH, but cautioned that this variable had not been investigated in depth.

Similar processes were described in a separate session in Paper Nos. C-10 and C-11 for phosphorus precipitation by "crystallization." The precipitates were reported to have handling and draining properties similar to that reported for the barium/radium sulfate. The study reported in Paper No. C-10 involved a fixed bed and that in Paper No. C-11 involved a fluidized bed. There appears to be significant potential for application of this type of modification for other industrial pollutants normally handled by conventional precipitation treatment.

D. Paper No. C-29: "Dynamics of Nitrification in a Biological Fluidized Bed Reactor" by S. W. Hermanowicz (U.S.A.) and J. J. Ganczarczyk (Canada).

Neither author being present, this paper was presented as a courtesy by Melcer (Canada) who professed lack of familiarity with the study reported. The paper described a mathematical model to simulate the nitrification process and use of a small-scale reactor to validate the model predictions. Following the presentation, Grady (U.S.A.), Molof (U.S.A.), and Block (The Netherlands) expressed concern regarding a possibly oversimplistic model and lack of control of important variables in operating the reactor. Since neither author was present to expand on the information contained in the written paper or respond to the concerns expressed by the audience, these issues could not be resolved.

E. Paper No. C-30: "Modeling, Optimization and Design of Fluidized Beds for Biological Denitrification" by Th. J. Nieuwstad (The Netherlands)

This paper described a model which attempted to incorporate the central role of nitrite in the denitrification process. The author claimed that this ion is ignored in other models purporting to simulate biological denitrification. The paper presented the derivation of the model which incorporated a large number of coefficients and compared its output with limited data collected on a small pilot denitrification column receiving nitrified activated sludge effluent.

The model provided a fairly accurate fit to experimental data collected along the fluidized bed; although it more accurately described the nitrate profile than the nitrite profile. Nieuwstad (The Netherlands) then applied the model to develop fluidized bed design criteria for biological denitrification. Example alternative designs were presented for identical influent conditions and effluent criteria. The author noted that final selection among such alternatives would be based upon an economic analysis. Jansen (France) congratulated the author on making a start on modeling a very complicated biological process, but noted that the model required many coefficients and constants that are not readily available, and whose values cannot be accurately established. Small changes in these values could radically affect model projected performance. The author concurred.

4. CRITIQUE OF SESSION

The papers in this session fell into two categories: industrial wastewater treatment and biological nitrification/denitrification. In the former category, Paper No. C-27 described a case study on reclamation for reuse of a semiconductor rinsewater. Paper Nos. C-26 and C-28 reported experimental studies from

Canada. Both studies were experimentally well designed. The paper on radium removal (Paper No. C-28), particularly in view of similar work reported in another session of the Conference, suggested an exciting and innovative modification to the conventional precipitation process.

The two papers on nitrification/denitrification, Paper Nos. C-29 and C-30, were less successful. Both were concerned with the development of mathematical models verified by limited experimental data. Questions on experimental protocols for Paper No. C-29 were unanswered due to the failure of the authors to appear. The denitrificaiton model described in Paper No. C-30 offered hope as a beginning point.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The principal contribution from this session involved the precipitation process innovation described in Paper No. C-28, particularly in light of parallel work described in another session in Paper Nos. C-10 and C-11. Industrial waste precipitation treatment sludges are frequently hazardous in character, and there is merit in process modifications which result in sludge volume reduction and/or increased sludge stability.

More limited but still worthy contributions resulted from the ion exchange study (Paper No. C-26) which expanded the technical literature on resin treatment of metal cyanide wastes and from the denitrification modeling effort (Paper No. C-30) which represented a beginning effort to incorporate the role of the nitrite ion in a descriptive process model.

1. SESSION

   A. Day: Thursday, September 20, 1984
   Location: Hall 1
   Time: 2:00-4:00 p.m.

   B. Theme of Session: Nitrification and Denitrification

2. REVIEWER

   A. Name: C. P. Leslie Grady, Jr.

   B. Position and Affiliation: R. A. Bowen Professor of Environmental Systems Engineering, Clemson University, Clemson, South Carolina (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-31: "Mathematical Model of Simultaneous Organic Oxidation, Nitrification, and Denitrification in Rotating Biological Contactors" by Y. Watanabe (Japan), S. Masuda (Japan), K. Nishidome (Japan) and C. Wantawin (Thailand)

This paper summarized experimental data collected in the authors' laboratory over the past six years and used to develop a mathematical model describing simultaneous carbon oxidation, nitrification, and denitrification in a rotating biological contactor (RBC). Because the data had been published elsewhere, the presentation in this paper was sketchy making the paper difficult to follow. Nevertheless, the paper presented some interesting concepts which improve the understanding of competitive growth of heterotrophic and autotrophic bacteria in RBC's.

The first concept explained why denitrification can occur in the presence of dissolved oxygen in the bulk liquid phase. More oxygen transfer occurs when the biofilm is in the air than when it is submerged. This is because the attached liquid film quickly becomes saturated with oxygen when in air, thereby providing a maximum driving gradient for oxygen diffusion into the biofilm. When a sector of biofilm is submerged, the oxygen concentration in the stagnant liquid layer drops as oxygen is transported into both the biofilm and the bulk liquid by diffusion. This causes the depth of oxygen penetration into the biofilm to decline. Because a given sector of biofilm is continually alternating between the air and the bulk liquid as the disk rotates, the dissolved oxygen profile is continually changing. It is this constantly changing profile that allows autotrophs and denitrifying heterotrophs to coexist at many places within the film. Furthermore, whenever a portion of the film becomes anoxic, denitrification can occur, thereby removing nitrate which had been formed when that region was aerobic or which had been transferred by diffusion from an adjacent aerobic region.

Another concept was that the rate of carbon oxidation is independent of the rate of nitrification, whereas the rate of nitrification decreases as the rate of carbon oxidation increases. This follows from the fact that carbon oxidation can occur through both aerobic and anaerobic respiration, whereas nitrification can only occur aerobically. An increase in the rate of carbon oxidation decreases the depth of oxygen penetration, thereby decreasing the space available for growth of nitrifiers within the film.

An important conclusion was that as far as nitrogen removal is concerned, there is an optimum partial pressure of oxygen in the gas space. Higher values reduce denitrification by allowing deeper oxygen penetration into the film. Lower values limit nitrate production, thereby limiting denitrification. The percent nitrogen removal at the optimum depends upon the relative carbon and nitrogen loadings. For this study the optimum partial pressure was 0.12 atm, but the generality of that finding is uncertain.

Perhaps the most controversial finding in this paper was that the amount of oxygen used by the biofilm was the same for a fixed disk operating condition, regardless of whether the film contained autotrophs, heterotrophs, or both. This suggests that oxygen transfer always controlled the performance. How general is this situation? The development of their model was based upon this observation and consequently the utility of the model depends upon its generality. The authors appeared convinced of the generality but are continuing to study it.

B. Paper No. C-32: "The Application of Predenitrification Nitrification Technology for Trace Contaminant Control" by H. Melcer and S. G. Nutt (Canada)

The purpose of this paper was to demonstrate that the achievement of high degrees of nitrification can be taken as evidence that a biological treatment system is also effectively removing trace organic contaminants. Therefore, it was postulated that nitrification could be used as a surrogate measure of trace contaminant control during treatment of complex industrial wastewaters.

The data used in this paper were collected over a six-year period during projects conducted to assess the utility of predenitrification-nitrification technology for the treatment of coke plant and coal liquefaction wastewaters. Both single-sludge suspended growth and separate-sludge fluidized-bed bioreactors were studied, although the former received only coke plant wastewaters. In addition to conventional parameters, the raw and treated wastewaters were analyzed for a number of polyaromatic hydrocarbons and heterocyclic nitrogenous compounds by GC/MS methodology. Whenever high degrees of nitrification were achieved, the trace organics were removed to concentrations below 10 μg/L. This observation served as the basis for their postulated use of nitrification as a surrogate measure. No attempts were made to correlate the degree of nitrification with the effluent concentration of any particular trace organic compound. In that sense the results were only qualitative.

In spite of the fact that several papers have already been published about the individual process studies, the entire discussion focused on various process questions, such as recycle ratios, and process stability. There was no discussion of the main point: that nitrification can be used as a surrogate measure for trace contaminant control. This is unfortunate, given the importance of many trace organics and the expense of analyzing for them. It would be very helpful to have some sort of surrogate technique. However, more work is needed to show that the majority of the important trace organics have sufficient impact upon nitrification to impair it when their concentrations are at significant levels.

C. Paper No. C-33: "Elevated Nitrite Occurrence in Bioloigcal Wastewater Treatment Systems" by J. E. Alleman (U.S.A.)

As a result of observations made during a number of research studies, Alleman (U.S.A.) became concerned with the potential for elevated nitrite levels during biological wastewater treatment. The purpose of this paper was to enumerate through a literature review the conditions under which elevated nitrite levels are likely to occur and to raise the awareness of environmental engineers concerning the potential for and consequences of such elevations.

Seven factors were discussed which can cause elevated nitrite levels, but four of them were related to the relative values of the kinetic coefficients for the two main genera of nitrifying bacteria. Two others involved process factors such as the mean cell residence time and one concerned "cryptic nitrate reduction" wherein nitrate formed during nitrification is partially denitrified to nitrite, presumably in microscopic anaerobic zones within macroscopically aerobic environments.

The invited discusser, Gujer (Switzerland), disagreed with Alleman's (U.S.A.) interpretation of the kinetic characteristics of the two nitrifying genera. Like most workers, he felt that *Nitrobacter* had a higher maximum specific growth rate than *Nitrosomonas*, thereby leading him to conclude that there were few circumstances under which elevated nitrite levels were likely to occur. This was exactly the point that Alleman (U.S.A.) was challenging, however. His data, as well as data from the literature, showed that *Nitrosomonas* has a higher maximum specific growth rate than *Nitrobacter*, at least under certain conditions. When that happens, elevated nitrite levels are likely to occur. One of the main points of Alleman (U.S.A.) was that the actual frequency of elevated nitrite levels is largely unknown because no one ever looks for it. Thus, the controversy can only be resolved by the collection of nitrite data on full-scale facilities.

During the open discussion, a number of individuals cited examples of elevated nitrite occurrence in both laboratory and full-scale systems. Furthermore, one discusser pointed out that the kinetics of nitrifying bacteria depended very much upon the species of organism involved. Thus, it should be possible to select a community in which the

Nitrosomonas species have higher maximum specific growth rates than the Nitrobacter species, and vice versa. The important point is that researchers have tended to generalize about a system with insufficient data and that generalization may well have caused one to overlook a potential problem.

Alleman (U.S.A.) outlined four environmental consequences associated with elevated nitrite levels, and Gujer (Switzerland) agreed that the consequences could be serious for fish and other organisms in receiving streams if elevated nitrite levels were discharged. Furthermore, one discusser cited a case in which elevated nitrite levels (≅10 mg/L as N) were responsible for the failure of the heterotrophic community to biodegrade a synthetic organic chemical, thereby suggesting that the consequences of elevated nitrite levels may be farther reaching than suggested by Alleman (U.S.A.).

Although no consensus was reached concerning the likelihood of elevated nitrite levels, it was clear that environmental engineers need to be aware of the problem and that data should be collected to ascertain the frequency of occurrence in real world systems.

D. Paper No. C-34: "Single Sludge Anoxic-Aerobic Systems for Biological Treatment of Coke Plant Wastewaters" by M. Beccari, A. C. DiPinto, R. Passino, R. Ramadori and V. Tandoi (Italy)

Even though this paper reported on a research study, its objective was very practical; to determine whether it was possible to treat a coke plant wastewater by the single sludge predenitrification-nitrification process without pretreatment to reduce the concentrations of phenol and ammonia. The study was conducted in two parts; the first using a synthetic wastewater containing all of the major constituents found in coke plant wastewaters, and the second using an actual wastewater. In both cases the wastes were diluted with tap water and the degree of dilution was reduced until reasonable treatment was no longer achieved. For the actual wastewater the limiting dilution was 1 part wastewater to 5.3 parts tap water, giving influent concentrations of 400 mg/L and 600 mg/L for total phenols and ammonia nitrogen, respectively. Under that condition, with a total mean cell residence time of 87 days and with 42% of the sludge under anoxic conditions, the effluent contained 10 mg/L of total phenols, 10 mg/L of ammonia nitrogen and 374 mg/L of nitrate nitrogen. Approximately 36% of the nitrogen was removed by denitrification. Thus, it was demonstrated that treatment could be obtained in a single sludge system. The data were used to estimate the total annual treatment costs associated with a plant treating 250 m^3/d of coke plant wastewater, and the value was found to be around \$4.5 (U.S.A.)/m^3 of waste treated. Melcer (Canada) pointed out that this was around 30 times more expensive than the processes studied at the Wastewater Technology Center where solvent extraction was used to recover phenol and stripping was used to remove ammonia before biological treatment. Thus, although it was shown that biological treatment was possible without pretreatment, the high dilutions and costs involved do not make it an attractive alternative. Nevertheless, the paper is significant in that it provides additional evidence concerning the application of single sludge technology to complex wastewaters.

An excellent discussion of the paper was provided by Ekama (South Africa) who pointed out that the use of a more fundamental kinetic approach would have allowed simulation studies to investigate the effects of different anoxic periods, etc. The wastewater contained an excess of nitrogen so that essentially all phenol was removed by denitrification. This suggested that a shorter denitrification period may have been possible, although the data were not sufficient to evaluate the possibility. In addition, although the data were insufficient to allow a thorough evaluation, they suggest that the thiosulfates in the coke plant wastewater may have been providing electrons for denitrification. Ekama (South Africa) suggested that additional data should be collected to allow an evaluation of the relative roles of heterotrophic and autotrophic denitrification in such wastes.

4. CRITIQUE OF SESSION

The first three papers in the session drew together information that had been presented elsewhere and used it to evaluate new ideas. Of the three, the first was the most difficult to follow because it presupposed too much familiarity with prior work. Nevertheless, all three presented ideas or concepts which are important and should be considered by the environmental engineering profession. The discussions of the first (Paper No. C-31) and third (Paper No. C-33) papers contributed materially to the points raised by the authors; however, the discussion of the second (Paper No. C-32) did not focus on the new concept being presented. This is unfortunate as that concept deserved and needed more discussion. The last paper (Paper No. C-34) was different from the others in that it presented new experimental data. However, as mentioned by the invited discusser, the data were incomplete, thereby preventing a thorough kinetic analysis from being performed. Thus, the utility of the last paper was limited to that of a demonstration of concept.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

All of the papers raised points which are significant to U.S.A. researchers and practitioners. Paper Nos. C-32 and C-34 both demonstrated that predenitrification-nitrification technology can be successfully applied to complex wastewaters containing toxic organic chemicals. Relatively little work has been done in the U.S.A. on this technology, but its benefits in terms of power and chemical costs suggest that more attention should be given to it. The first paper (Paper No. C-31) suggests that operators of RBC systems may be able to achieve significant nitrogen removal through proper manipulation of the vent opening in the covers. Two types of research will be needed to implement such control, although one can be performed on full-scale systems to provide proof of concept. In addition, modelers should investigate the operational conditions most likely to result in optimal nitrogen removal using the more mechanistically based models commonly employed. There is considerable interest in the U.S.A. in the possibility of using some sort of surrogate method to provide evidence for removal of toxic pollutants to low levels. Thus, the concept presented by Melcer (Canada, Paper No. C-32) has a certain appeal. However, the idea needs much more study before it can be adopted. Finally, the point raised by Alleman (U.S.A., Paper No. C-33) concerning the appearance and significance of nitrite in biologically treated effluents needs more attention. At the very least, more complete data should be collected on full-scale facilities to determine whether a real problem exists.

1. SESSION

A. Day: Monday, September 17, 1984
Location: Hall 2
Time: 2:00-5:25 p.m.

B. Theme of Session: Land Treatment of Waste and Wastewater

2. REVIEWER

A. Name: Charles P. Gerba

B. Position and Affiliation: Associate Professor of Microbiology and Nutrition and Food Science, University of Arizona, Tucson, Arizona (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

A. Paper No. C-35: "Epidemiological Evidence of Helminth and Cholera Transmission by Vegetables Irrigated with Wastewater--A Case Study" by H. I. Shuval, P. Yekutiel and B. Fattal (Israel)

Epidemiological studies on health effects related to land application of sewage are difficult to perform and are costly. As a result, little information exists on direct relationships between the use of raw sewage for irrigation of food crops and enteric disease, although it is not practiced in the U.S.A. Due to a series of historical events, a situation developed in Jerusalem which allowed for a retrospective study on the causal relationship between disease in the population and exposure to wastewater irrigation. During the years 1935-47, the city of Jerusalem was supplied with vegetables which were irrigated with untreated wastewater and the isolation of *Ascaris* in the population complaining of diarrhea was 35%. After the war of independence in 1948, the city was partitioned and the supply of vegetables was discontinued to one part of the population. During these years the isolation of *Ascaris* decreased to below 1%. The city was reunited in 1967 after the six-days war and wastewater irrigation was then reintroduced. At this time, the isolation of this pathogen again began to increase to 13%. Finally in 1970, after an outbreak of cholera, the government outlawed the use of raw wastewater for food crop irrigation and again the incidence of Ascaris dropped to below 1%. This report clearly demonstrated that caution must be exercised when considering the use of wastewater for vegetable crops which may be eaten raw and, if used, pretreatment is imperative.

The author emphasized that the results should not discourage the use of domestic wastewater for crop irrigation. Economical engineering solutions, such as oxidation ponds, can be used to eliminate pathogenic viruses and parasites. Agreement with the suggested use of oxidation ponds was voiced by other workers in Israel who pointed out that 70-day retention times were needed for complete virus removal. It was also mentioned by Issaard (Sweden), the discusser, that, while the risk of enteric infection may be signficant from consumption of vegetable crops irrigated with raw sewage, occupational risks among farm workers appear to be low.

B. Paper No. C-36: "Wastewater Treatment by Artificial Wetlands" by R. M. Gersberg, B. V. Elkins, and C. R. Goldman (U.S.A.)

This paper was an investigation into the removal of BOD, suspended solids, and nitrogen at artifically treated wetlands at Santee, California. Primary effluent and blends with secondary effluent were passed through beds containing emergent vegetation. At an application rate of 6 cm/d, the study showed that 6.48 ha of constructed wetlands would be required to treat 3785 m^3 of primary wastewaters to secondary treatment levels (i.e., BOD and suspended solids). When blends were used, the wetland effluent values for both BOD and suspended solids were below standard for advanced secondary treatment.

The author also emphasized the high nitrogen removal achieved (80% for total nitrogen) and the economic aspects of treatment by wetlands for small to medium sized communities. He further pointed out that substantial pathogen removal occurred during treatment, but did not provide actual experimental data.

During the discussion it was pointed out that removals may be treatment dependent and that climate may have a major influence on the processes of BOD and nitrogen removal. Problems associated with algae and duckweed in the discharge from the wetlands was concern voiced by the discusser, Butijn (The Netherlands). The author indicated that during the first year of operation these organisms grew in substantial numbers, but once the emergent vegetation was established, enough shade was present to control the growth of these nuisance organisms. Mosquito control was another problem encountered. To reduce this problem the water level in the artificial beds was allowed to drop below the surface for periods of time. This was possible at the site because of the gravel surface of the beds, but would not be possible with finer textured soils.

C. Paper No. C-37: "Use of Peracetic Acid in Operational Sewage Sludge Disposal to Pasture" by J. A. L. Fraser, A. F. Godfree, and F. Jones (United Kingdom)

Economical methods of sludge disinfection are necessary for its safe and unrestricted use on agricultural lands. The authors of this paper reported on the effectiveness of peracetic acid as an ovicidal and bacterial agent in raw, digested and activated sludges. Concentrations of from 100 to 250 mg/L of PAA (a proprietary compound containing 36% to 40% peracetic acid) resulted in a 99% to 100% destruction in viability of tapeworm embryos and five log reductions in Salmonella in sludges. At these concentrations the PAA was rapidly utilized and broken down into harmless byproducts. Even at concentration applications of 1000 mg/L, less than 2% remained after 12 minutes. The sludge can be disinfected during land application as no phytotoxic effects have been observed. Treatment costs for removal of Salmonella with PAA were as low as $0.75/wet ton of raw sludge.

The author mentioned that with disinfection the "no-grazing" interval after sludge application, commonly practiced in England, could be eliminated or reduced to a few days. The discussion centered around the usefulness of the PAA against Ascaris and viruses. The author responded that PAA prevents hatching of Ascaris eggs at a concentration of 500 mg/L. Limited data indicated that PAA was also effective against coxsackie-, echo-, and polio-viruses, but it was not stated whether this work was done with sludge. The results of the work would have been more useful if virus data had been included.

D. Paper No. C-38: "Considerations on Water, Oil and Air in Porous Media" by H. O. Schiegg (Switzerland)

Hydrocarbons spilled on the soil surface above an unsaturated zone will percolate primarily vertically until they reach the capillary fringe. The oil then migrates within the capillary fringe parallel to the groundwater table. Schiegg (Switzerland) attempted to mathematically describe the mean thickness of such an oil polluted layer as a function of the thickness of oil in an observation well and of the oil potential. It was concluded that the average thickness of an oil-polluted layer parallel to the groundwater table was not equal to the thickness in an observation well, but could be described as a function of the mean capillary height for water in air and the potential or the thickness of oil in an observation well.

The discusser pointed out that predictions of the thickness of the oil layer should take into consideration fluctuations in the water table.

E. Paper No. C-39: "Leachate Attenuation in the Unsaturated Zone Beneath Landfills: Instrumentation and Monitoring of a Site in Southern England" by H. D. Robinson and J. L. Lucas (United Kingdom)

This long-term study was designed to evaluate the effectiveness of engineered semi-permeable attenuation blanket (unsaturated zone) in the field for the reduction of pollutants in leachates from domestic landfills. A six-meter attenuation zone was constructed as the bed for a major landfill in the South of England. Over 100 sampling and monitoring instruments were installed within this unsaturated zone before disposal was begun. Water samples from both the saturated and unsaturated zones, gas samples from the unsaturated zone, electrical conductivity, and temperature, were obtained from numerous locations throughout the site at quarterly sampling intervals. Major conclusions were that the unsaturated zone rapidly becomes anaerobic as a result of the migration of landfill gases through it, well in advance of any leachate front. The high buffering capacity of the attenuation zone material has prevented reduction in pH values, and the appearance of high concentrations of ammonia found elsewhere in leachates at the base of the landfill did not occur, probably as a result of cation exchange processes.

The authors emphasized that biological degradation of organic contaminates was likely to be more rapid when the leachate reached the saturated zone. The purpose of the unsaturated zone is to control the rate of seepage of leachate into the saturated zone, such that the residual contaminant load is balanced by a continuous supply of oxygen in the groundwater underflow. The author also commented that their results should not be compared to industrial waste sites where toxicity may present problems with the degradation of the organic wastes. Heavy metals were only detected in low concentrations and were not seen as a major problem by the authors. No attempts were made to analyze the leachates for volatile organic carbon or other trace organics. A comment made by van der Schroef (The Netherlands) indicated adsorbed ammonia could desorb once the unsaturated zone became saturated with ammonia.

4. CRITIQUE OF SESSION

The papers presented varied greatly in subject matter. Paper No. C-35 was very good in providing rather solid epidemiological data on health hazards associated with irrigation of food crops with raw wastewater. Paper No. C-37 provided information on the use of peracetic acid for destruction of two important animal pathogens. While the use of this compound appears promising, data on human pathogens such as viruses would have made the study more useful. The study of wetlands for treatment of wastes (Paper No. C-36) demonstrated the usefulness of these systems for BOD and suspended solids removal, but left many unanswered questions such as pathogen removal and problems with nuisance insects and algae. Paper No. C-38 was largely descriptive of processes needing field study. Paper No. C-37 described the beginnings of an extensive long-term monitoring effort whose long-term results will be more significant.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The two studies on pathogen occurrence during land disposal of domestic wastes provided additional information for the implementation of guidelines for these practices in the U.S.A. The use of peracetic acid disinfection of sludges to allow unrestricted disposal of sludge warrants further study. The extensive monitoring effort underway at the landfill site in England on the use of attenuation zones should provide long-term useful information for the design of such sites in the U.S.A.

1. SESSION

   A. Day: Tuesday, September 18, 1984
      Location: Hall 2
      Time: 9:00 a.m. to 12:25 p.m.

   B. Theme of Session: Sludge

2. REVIEWER

   A. Name: Charles R. O'Melia

   B. Position and Affiliation: Professor, Department of Geography and Environmental Engineering, The Johns Hopkins University, Baltimore, Maryland (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-40: "Settling of Nutrient Removal Activated Sludges" by A. R. Pitman (South Africa)

The author presented an approach to the design and operation of final clarifiers based on an analysis of data from four full-scale biological treatment plants for nutrient removal. Results of batch tests based on solids flux theory were analyzed using Vesilind's equation, $V_s = V_o e^{-nX}$, where V_s is the settling velocity of a sludge with concentration X and V_o and n are empirical constants derived from the batch experiments. Excellent correlations were found between the ratio V_o/n and two simpler traditional measures of sludge settling properties, SVI (sludge volume index) and SSVI (stirred specific volume index). The author presented procedures by which an operator or designer could use measurements of SVI or SSVI and, through the empirical correlations with the V_o/n, determine upflow velocities and recycle ratios for use in operation or design.

In addition to this quantitative method for the design and operation of final clarifiers, the author presented some qualitative conclusions from experiences with the four plants. First, two extended aeration plants showed better settling properties than two Phoredox/Bardenpho units. Second, good phosphorus removal was accompanied by poor settling properties in one plant. Third, filamentous organisms produced poor settling properties; these organisms were associated with low organic loadings (F/M ratios) and low dissolved oxygen concentrations.

The formal discussion was presented by Le Blanc (France). He focused his discussion on: (1) the data base used in the empirical correlations between SVI and V_o/n (most data were obtained from two of the four plants using the Phoredox/Bardenpho process); (2) the possible effects of treating unsettled sewage in two of the plants, since the higher mineral content in the waste inflow could improve settleability in the secondary clarifiers; (3) the possibility that denitrification was not complete in the anaerobic zone, so that it may have occurred in the settling tanks; and (4) the possibility that low organic loadings in plants with D.O. greater than 1 mg/L could have stimulated filamentous organisms.

In the general discussion, it was pointed out that SVI is not a good measure of settleability due to its dependence on sludge concentration. The diluted SVI as used in the Netherlands and West Germany was proposed as an improvement. Data were presented indicating that the results of Pitman (South Africa) compared well with data in the literature. It was noted that data from real plants indicate that the flux theory overestimates solids loading capacity by about 20%.

In his reply, Pitman (South Africa) acknowledged that few data were obtained from the extended aeration plants due to interest in the other systems. However, the data from all plants were taken over an extended time (four years) and should thus cover a range of conditions. While the MLVSS could be used to account for mineral matter for plants treating unsettled sewage, measurements were made and variation among the plants was small. MLVSS varied from 0.75 to 0.78 of MLSS. A synergistic effect with loading (F/M ratio) and oxygen was found with the filamentous organisms. As soon as aeration was reduced, filamentous organisms appeared. They persisted for long periods after aeration was again increased. Pitman (South Africa) agreed that the diluted SVI is a better indicator of sludge settling properties and is using it in his present work.

B. Paper No. C-41: "Sludge Conditioning: Effects of Sludge Biochemical Composition" by P. T. Bowen and T. M. Keinath (U.S.A.)

This research was conducted to determine the effects of biochemical components of sludges on dewaterability and on polymer requirements. Biochemical components measured were the protein, carbohydrate, and lipid contents. Other sludge properties measured were pH, charge density, and particle size distribution. Dewaterability was measured by specific resistance and capillary suction time. Polymer effectiveness was expressed as the polymer index, PI, the minimum polymer dosage required to achieve maximum dewaterability. Three sludges from two plants were tested: a primary sludge, a waste activated sludge, and an anaerobically digested sludge.

Only lipid content was observed to have a statistically significant correlation with dewaterability. Increasing lipid content was accompanied by increased values of specific resistance and capillary suction time. The authors attributed this effect to the presence of lipid in the supracolloidal size fraction of digested sludges. However, they did not observe any correlation between particle size distribution and dewaterability.

Several sludge properties correlated with polymer requirements (PI). The lipid, protein, and carbohydrate fractions and the pH showed statistically significant correlations with dosage requirements for cationic polymers. The PI increased with lipid content and with pH and decreased with increasing carbohydrate and protein contents. The authors discussed some of these effects in terms of surface charge (e.g., the pH correlation), but did not observe a correlation between the charge density of the sludge and PI.

The formal discussion was presented by den Engelse (The Netherlands) who raised five points. First, was it valid to extrapolate from three sludges (taken from two plants) to the diverse spectrum observed in practice? Second, lipids can be destroyed in digesters if they are operated to do so, as is done in the Netherlands. Would this improve the dewaterability of digested sludges? Third, what was the dry metal content of the sludges? Should it affect dewaterability? Fourth, was there a correlation between specific resistance and capillary suction time? Which is preferred? Finally, is the polymer index (PI) a good method of describing sludge dewaterability?

In the general discussion, Saunders (U.S.A.) raised two issues. First, the analytical procedures used for measuring carbohydrate content may not measure the same substances in different sludges and so the results may not be comparable. Second, polymer index (PI) could vary with sludge solids concentration, also complicating comparisons among sludges.

In his reply, Bowen (U.S.A.) indicated that the treatment plants and the sludges were similar. Dry matter contents in the sludges did not vary in a statistically significant manner. No correlation was attempted between specific resistance and capillary suction time (CST); these were used as independent tests. Bowen (U.S.A.) preferred CST because it is quicker. The polymer index (PI) was not used as a measure of dewaterability. Rather, it was used to rate polymers. In evaluating the analytical method used for determining carbohydrate content, samples were spiked with a mixture of sugars and recovery of all sugars was excellent. Variations of polymer dosage with sludge solids concentration were minimized by attempts to hold solids concentration as constant as possible.

C. Paper No. C-42: "Floc-Forming Substances Extracted from Activated Sludge with Ammonium Hydroxide and EDTA Solutions" by T. Sato and Y. Ose (Japan)

These authors obtained activated sludge from a municipal wastewater treatment plant and subjected it to sequential extraction using NH_4OH and EDTA. Four supernatants and two precipitates were obtained. The floc-forming properties of these six products were tested by adding each to kaolin suspensions and varying pH. Kaolin concentration was 270 ppm, extract concentration was 100 ppm, and pH was varied from 1 to 13. The authors concluded that low molecular weight substances (molecular weight 2000-3000) that were not metal ions were able to flocculate the kaolin suspensions at low pH.

There was no formal discussion of this paper. During the open discussion, some questions were asked about methodologies for analyses of carbohydrate, protein, and nucleic acids, and about mechanisms for metal ions in the flocculation process. The speaker had difficulty in responding to questions and stated that this was due to his limitations with the English language.

D. Paper No. C-43: "Highly Efficient Anaerobic Digestion with Thermal Pretreatment" by M. Hiraoka, N. Takeda, S. Sakai, and A. Yasuda (Japan)

The authors conducted batch and pilot plant studies of thermal pretreatment (60-100°C) of waste activated sludge and its effects on anaerobic digestion. The approach is based on the hypothesis that hydrolysis of particulate matter is the rate-limiting step in anaerobic digestion.

Laboratory studies used waste activated sludge that was heated prior to anaerobic digestion. In pilot-plant studies, waste activated sludge was heated and then mixed with unheated primary sludge prior to digestion. Both laboratory and pilot plant studies showed increased gas production with thermal pretreatment. Such pretreatment increased the overall destruction of organic matter by only a few percent below 80°C. However, thermal pretreatment in the temperature range 80° to 100°C significantly increased the destruction of organic matter. The authors proposed two processes in interpreting the results of thermal pretreatment: destruction of volatile solids, and depolymerization of fats and carbohydrates. They suggested that volatile solids destruction occurred during pretreatment in the lower (60-80°C) temperature range, with depolymerization occurring at the higher (80-100°C) range.

Malina (U.S.A.) indicated that these studies, combined with previous studies by other investigations at higher temperatures, provide an extensive examination of the effects of temperature and pressure in pretreatment of sludges prior to anaerobic digestion. He indicated that the data from the laboratory studies do not require two mechanisms for interpretation. One process, cell solubilization (analogous to depolymerization) could in his opinion explain the data. He also suggested that emphasis in the paper on organic loading could be reinterpreted in terms of hydraulic detention time, with failure occurring at detention times of 6 to 10 days, rather than at loadings in the order of 3 kg VS/m^3-d. Comparison of laboratory and pilot plant studies is hindered by the fact that they used different inputs to the digestion step, i.e., waste activated sludge in the laboratory studies and a combination of waste activated sludge and unheated primary sludge in the pilot-scale studies. The engineering significance of the work is restricted by the lack of an economic analysis. Given the spectrum of temperatures and pressures available for thermal pretreatment, what conditions are most economical? Finally, Malina (U.S.A.) indicated that future studies of the process should include determination of gas composition, formulation of a COD balance, and evaluation of the dewatering characteristics of the digested sludge.

In his reply, Takada (Japan) stated that present work includes a COD balance and experiments that indicate that protein hydrolysis occurs in the process and can increase methane production. An economic analysis was not made, but the authors anticipated that energy costs for low-temperature thermal treatment will not be excessive and that the process will be economical.

E. Paper No. C-44: "Production of Liquid Alum from Aluminum-Anodizing Sludges" by F. M. Saunders and C. B. Harmon (U.S.A.)

Aluminum-anodizing sludges are produced by neutralization of rinse waters and other waste streams from the aluminum extruding industry, followed by sedimentation, thickening, and dewatering. Dewatered sludges typically range in concentration from 9% to 15% as dry solids with some instances of solids concentrations in excess of 21%. These concentrated sludges can be converted to liquid alum by acidification with sulfuric acid at temperatures of 100°C. Liquid alum solutions of strengths comparable to commercial alum (8% to 8.3%) can be achieved if the original waste sludges have dry solids concentrations in excess of 21%. For more dilute sludges, additional process modifications or sludge treatment is necessary to produce commercial strength products.

Formal discussion was presented by Ericsson (Sweden). He noted that the recovery of aluminum from sludges in water treatment plants has been extensively investigated. Dry methods have proved uneconomical because of energy costs. Wet methods such as sulfuric acid extraction can be limited by product quality (dissolved organic matter and iron, for example) and by the solids concentration in the waste sludge. Apparently, quality problems are not encountered with aluminum-anodizing sludges, but the solids concentration problem is also encountered with these materials.

Ericsson (Sweden) stated that the dewatering of water treatment plant sludges could be improved by appropriate use of polymers and agitation and by membrane filter presses. He then asked about filtration experiences in the aluminum-anodizing industry. He inquired about the selection of 550°C in the determination of inert solids (in place of 600°C), and whether liquid ion exchange had been considered as an alternative process to acidification.

Saunders (U.S.A.) reported that no single filtration process seemed preferable to others, that 550°C was used in determining inert solids because it was convenient in his laboratory and that liquid-liquid ion exchange had been studied, found to be technically feasible, and was dismissed as being uneconomical.

In open discussion, questions dealt with details of the paper and the possibility of preparing aluminum chloride and polyaluminum chloride solutions from the aluminum-anodizing sludges.

4. CRITIQUE OF SESSION

The content and discussion for the first paper (Paper No. C-40, South Africa) were the best in the session. The author provided a useful, practical procedure for designing secondary clarifiers based on simple laboratory tests. Statements by the author about effects of extended aeration, dissolved oxygen, phosphorus removal, and other variables on clarification are less well founded and should be considered as hypotheses or speculations. The paper provided a focus for some important evaluations of field experiences by the discussers.

Paper No. C-41 (U.S.A.) contained some interesting data relating sludge properties to sludge dewatering and polymer requirements. While the results do not permit unambiguous theoretical analysis or practical application, they do suggest plausible new research directions. The effects of lipid content on sludge dewatering and the possibility that it can be controlled by digester design and operation is an example.

Paper No. C-42 (Japan) was below average in quality. The authors presented results that disagree with other work in this field. They report low molecular weight organic substances as being important for floc formation in activated sludge. In the opinion of the writer, it is possible that the single dosage used in the experiments was so high that good floc forming substances (e.g., high molecular weight polymers) were present in sufficient quantities to stabilize or peptize the suspensions, thereby masking the floc forming abilities of these extracts.

The fourth paper (Paper No. C-43, Japan) was good and the formal discussion was excellent. Some good work has been done in thermally treating sludges prior to anaerobic digestion, and this present work is a useful addition to the area. As pointed out in the discussion, there is now available sufficient information to make determinations of economic feasibility, and this should be done.

Paper No. C-44 (U.S.A.) contains a systematic and straightforward examination of a problem in which reuse of aluminum is attempted. Technology is now available, although some improvements may be needed. Costs are the problem, and this work demonstrates that economical reuse of aluminum may be feasible.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The following conclusions are suggested by the papers in this session and by discussion within the session and subsequent to it.

It is possible to develop empirical relationships between simple settling tests (e.g., SVI) and solids flux theory and to use this approach in designing and operating secondary clarifiers. The diluted SVI may be the preferred settling test for this approach. Comparison with field data indicates that the solids flux theory overestimates clarifier capacity by about 20%.

There may be relationships between biochemical sludge properties (carbohydrate, protein, and lipid content) and sludge dewaterability and polymer requirements. Additional research is needed to understand these effects and to quantify them.

Thermal pretreatment can increase gas production and the destruction of organic material in anaerobic digestion. Benefits are plausible at pretreatment temperatures as low as 60°C.

Aluminum can be recycled from waste sludges by acidification with sulfuric acid. Economical operation depends upon sludge solids concentration, and hence on solid-liquid separation and dewatering.

1. SESSION

   A. Day: Tuesday, September 18, 1984
   Location: Hall 2
   Time: 2:00-5:25 p.m.

   B. Theme of Session: Sludge

2. REVIEWER

   A. Name: Paul T. Bowen

   B. Position and Affiliation: Assistant Professor, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, Oklahoma (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-45: "Sludge Treatment Technology and Ionizing Radiation" by M. Sedlacek, M. Koubik, K. Vacek and J. Rejholec (Czechoslovakia)

The authors of this paper were not present.

This paper described the effects of radiation hygienization of sludges and the subsequent use of these sludges for agricultural purposes. Irradiation was reported to improve sludge thickening, but increased dosage requirements for chemical sludge conditioning. Salmonella seni. were eliminated from the sludge by irradiation and reinfection was suppressed. Field studies revealed higher yields when irradiated sludge was added as a soil conditioner than when nonirradiated sludge was added. The paper also included a brief discussion of the economic aspects of this method of disinfection for Czechoslovakia where radiation sources can be easily obtained.

Discussion focused on the overall benefits of irradiation processes. Questions were raised regarding the location of the irradiation process before or after dewatering. After dewatering and prior to incorporation in the soil matrix was concluded as the optimum location.

B. Paper No. C-46: "Sludge Stabilisation and Disinfection by Means of Autothermal Aerobic Digestion with Oxygen" by B. C. Trim and J. E. McGlashan (South Africa)

McGlashan (South Africa) described a pilot-scale autothermal aerobic digestion process for sludge which used pure oxygen. The project objective was to demonstrate that sludge produced from this process was stabilized and disinfected. Results showed that complete inactivation of *Ascaris* ova occurred. Sludge produced in this process appeared stable if left standing for several days; but when inoculated with anaerobic sludge, the treated sludge fermented readily.

Discussion centered on three aspects of this paper: stability of the sludge, economics of the process, and degree of disinfection. Since the sludge fermented readily on inoculation with anerobes, the degree of stabilization was questioned by van der Graff (The Netherlands). He suggested an increasing oxygen input as a means of improving stability.

The economics of pure oxygen systems were also discussed by van der Graff (The Netherlands) and Fleckseder (Austria). In pure oxygen systems, less gas volume is required to satisfy aerobic conditions, thus the cooling effect and shear force are less. However, air has been used in German facilities with considerable success. Oxygen systems generally are more expensive than air systems.

Ascaris ova were used as indicator organisms for disinfection of the sludge. Law (Australia) pointed out that these organisms have a low heat threshold. Other pathogens may be viable, even if *Ascaris* were completely killed. The authors offered no correlation between *Ascaris* and other pathogens.

Sludge produced from autothermal aerobic systems was found difficult to dewater and settled slowly. Increasing solids content of sludge input to the process (Gregor, Federal Republic of Germany); increasing the oxygen to VSS ratio (van der Graff, The Netherlands), and following the system with anaerobic digestion (Law, Australia) were suggested for improving sludge dewaterability.

C. Paper No. C-47: "Decontaminating Biological Sludge for Agricultural Use" by L. Wong and J. G. Henry (Canada)

To use sludges for agricultural purposes, heavy metals present in the sludge must be removed without destroying the nutrients or organic matter. Wong (Canada) presented a biological process which solubilizes heavy metals present in wastewater sludge. Bacterial leaching was investigated to determine pH, temperature and degree of aeration for maximum removal.

Bacterial leaching was borrowed from hydrobiological mining. Thiobacillus ferrooxidaus is the bacterium responsible for solubilizing the metals in the sludge. This process produced a sludge low in metals without decreasing its agricultural value. In some cases, the nutrient concentrations were increased and organic matter slightly reduced by the process.

For agricultural disposal of sludge, this process offers a way to improve sludge quality. However, Banerji (U.S.A.) pointed out that a supernatant high in metals concentration is produced by this process. Because of this increase, the problem of metal disposal still exists. Higher metal concentrations may allow recovery or fixation processes to be applied. Banerji (U.S.A.) also discussed the influence of toxic organics in sludges on this type of biological process. The dewaterability of the sludge was not discussed by the author or discusser.

D. Paper No. C-48: "Fractionation of Heavy Metals in Sewage Sludges" by R. J. Oake, C. S. Booker, and R. D. Davis (United Kingdom)

Campbell (United Kingdom) presented this paper on sequential extraction of metal fractions from sludges. The exchangeable, sorbed, organic, carbonate and sulfide fractions of cadmium, chromium, copper, nickel, lead and zinc were isolated.

Campbell (United Kingdom) briefly discussed this procedure before highlighting the change in mobility of metals following sludge disposal. The six metals were associated with labile (exchangeable, sorbed and organic) and nonlabile (carbonate and sulfide) fractions. As storage time increased, the labile fraction of copper, zinc, cadmium and lead increased in activated sludge. The longer activated sludge is held prior to disposal, the more likely metals are to be found in the labile fraction. Raw or digested sludges showed decreases or erratic results for all metals in the labile fraction.

Questions regarding the specificity of the sequential extraction procedure used by the authors were raised by Marchandise (France) and Chandhuri (India). The specificity of the extractants may not be as narrow as claimed in the literature. Earlier work by the authors and correlations developed for this report suggested the procedure was adequate and reproducible.

E. Paper No. C-49: "Controlling Metal Uptake from Heat-Treated Sludge Applied to Grasslands" by J. W. Vail and D. G. Devey (South Africa)

Vail (South Africa) reported results of using Zimpro heat-treated sludge to enhance pasture development and turf growth in South Africa. United Kingdom application criteria for sludges containing metals were used as study guidelines.

Zimpro sludge was found to be friable and easily handled. No pathogens were present and no noticeable odor occurred during use. This sludge also contained adequate nitrogen and phosphorus for agricultural use. Nitrogen limits were not followed because nitrogen in the sludge was used slowly. The authors felt metal concentration should limit application rates, not nitrogen content.

Soil in the pasture land study had a pH greater than 8. In the turf production experiments, the soil had a pH of 5.5. Both sites showed improved grass production with sludge application. Despite deliberate high loadings, no phyto- or zoo-toxicity was observed by the authors. However, Hallquist (Sweden) discussed the lack of metal uptake analysis by animals. No analysis of internal organs or flesh of cattle exposed to increased metal concentrations were performed. As expected, grasses in the lower pH soil showed a higher metal uptake than on the other soil.

4. CRITIQUE OF SESSION

All of the papers dealt with wastewater sludges. Paper Nos. C-45 and C-46 discussed disinfection of sludges for agricultural use. Paper No. C-48 was an evaluation of metals associated with sludges. Metal migration from sludges to soil and plants was the subject of Paper No. C-49. Bacterial leaching of metals from sludges to enable agricultural use was discussed in Paper No. C-47. All projects except Paper Nos. C-47 and C-48 were field-scale projects.

Although Paper No. C-45 presented a successful means of sludge disinfection, the economics of radiation disinfection need to be evaluated further. Potential handling problems and public concerns must also be addressed. Data for the autothermal aerobic digestion process (Paper No. C-46) revealed that the system did not perform as well as the authors suggested. The system did not achieve effective disinfection nor did it improve dewaterability. No new information regarding sludge application to soils for agricultural use was presented in Paper No. C-49.

A bacterial leaching process for removing metals from sludge (Paper No. C-47) appears promising. However, the economics and kinetics of this treatment have not been developed. Metal fractionation by sequential extraction (Paper No. C-48) is another promising area. The results on labile and non-labile metals are meaningful and interesting.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The work presented in the majority of these papers is of limited value. Most of the developments were empirical and were not extrapolated to fundamental solutions. However, Paper No. C-47 described a well conceived process for removal of metals from sludges. Although questions on the exact procedure need to be developed, further work in this area should be encouraged.

The sequential extraction procedure (Paper No. C-48) is of interest. As presented, the work is high quality and the results show valuable information can be obtained. This procedure has merit and could provide useful data on metal mobility in sludges. Support for additional work in this area is suggested.

1. SESSION

   A. Day: Wednesday, September 19, 1984
   Location: Hall 2
   Time: 9:00 a.m. to 12:30 p.m.

   B. Theme of Session: Disinfection; Modeling; and Virology

2. REVIEWER

   A. Name: Judith B. Carberry

   B. Position and Affiliation: Associate Professor, Department of Civil Engineering, University of Delaware, Newark, Delaware (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-50: "Disinfection of Drinking Water Rich in Bromide with Chlorine and Chlorine Dioxide, While Minimizing the Formation of Undesirable By-Products" by Ch. Rav-Acha, A. Serri, E. (Goldstein) Choshen and B. Limoni (Israel)

The presenting author, Rav-Acha (Israel), explained that the conventional disinfection process using chlorine, when applied to drinking water sources rich in bromide, will produce significant concentrations of trihalomethanes (THM). This class of compounds is potentially carcinogenic. On the other hand, the use of chlorine dioxide on such bromide-rich waters converts approximately one half of the applied oxidizing agent to chlorite ion (ClO_2^-). Chlorite ion is also undesirable from a public health standpoint.

The presenting author detailed the results from a study in which simultaneous and staggered doses of ClO_2 and Cl_2 were applied to water taken from Lake Kinneret. The staggered application allowed disinfection first by ClO_2, with less THM production than in the simultaneous dosing procedure; subsequent application of Cl_2 then oxidized any ClO_2 which had been produced from the first-stage dose of ClO_2. The author concluded that, for bromide-rich waters, this staggered application procedure is very beneficial to minimize the production of THM's, in contrast to the very high ratios of oxidizing agents necessary to minimize THM's when ClO_2 and Cl_2 are applied simultaneously.

A sharp discussion followed when the formal discusser, van Steenderen (South Africa), claimed that severe lack of data in the paper marred the benefits claimed by the author. Van Steenderen (South Africa) claimed that his process of pre-ozonation followed by chlorination provided maximum benefit with little THM production, as well as the advantages of a measurable breakpoint chlorination and residual chlorine.

Adin (Israel) commented that the staggered chlorine dioxide and chlorine application process described by the author was much more economical than the cited pre-ozonation process. Narkis (Israel) commented that the breakpoint consideration was irrelevant for the application of ClO_2. Kott (Israel) suggested that the author might conduct follow-up studies on prechlorinated Kinneret waters. Such studies would be advisable since, in Israel, the Kinneret water is chlorinated during its transmission enroute to Israel's major metropolitan areas. Bishop (Australia) stated that the author should have identified the THM's produced from prolonged exposure of Kinneret water to Cl_2. The author responded that the direct chlorination of Kinneret water produced 95% bromoform from the action of oxidized bromide ion on organic THM precursors.

B. Paper No. C-51: "Sunlight Photooxidation of Organic Pollutants in Wastewater" by A. J. Acher (Israel)

The author could not attend the conference, but his paper was included in the preprinted proceedings. The author had studied a method of purifying agricultural irrigation water by injecting UV sensitizers such as methylene blue (MB), rose bengal (RB), or algal chlorophyll into wastewater treatment plant effluents containing residual surfactants, E. coli, bacteriophages and pesticides. The stream was then exposed to sunlight for approximately six hours at an intensity of $1950 \pm 50 \mu E/m^2$-s, and any excess UV sensitizer was then "precipitated" by additions of bentonite clay at a ratio of eight parts bentonite to one part sensitizer. At an optimum MB concentraitn of 12 ppm, 70% COD and 90% MB were removed. Similar experiments with inoculated effluents showed that inverse relationships of sunlight intensity and exposure time reduced coliform concentrations to non-detectable levels.

The discusser, Omura (Japan), pointed out that this treatment process was particularly promising for emerging countries, three-fourths of which were in warm latitudes. He pointed out several inadequacies in the paper such as the presence of unknown refractory organics present in the effluent. These comments went unanswered due to the author's absence.

Kott (Israel) commented that he had seen the process operating at a pilot-plant scale and that the process produced quick bacterial kill and viral inactivation, but the problem remained as to how to eliminate the unreacted sensitizer before the treatment stream could be applied to the soil for irrigation purposes.

C. Paper No. C-52: "Synthesis Modelling of Municipal Wastewater Treatment Systems" by A. S. Camara (Portugal), C. W. Randall (U.S.A.) and L. C. Fair (U.S.A.)

Randall (U.S.A.) presented a very clear, understandable description of work on a combinatorial optimization model consisting of object functions with cost constraints formulated from two interpretive algorithms--one for liquid flows and one for solid flows. He presented two slides of the algorithm diagrams (shown in the paper) and explained that due to the complexity of the optional flow paths illustrated in these diagrams, a suboptional approach was used for each optional pathway in each treatment stage. The sums of suboptional solutions for each design then could be combined with any suboptional solution for a subsequent stage or the treatment could be terminated at any stage with resulting treatment efficiencies and costs determined. For example, the overall design specifications could be determined for various preliminary, primary and secondary treatment schemes, with or without additional tertiary treatment. The costs and resulting efficiencies could be determined for any of these combinations, including, most importantly, the cost of resulting sludge treatment and disposal. Thus the model attempted to provide a cost/benefit analysis for any consumer or designer. Randall (U.S.A.) pointed out several deficiencies in the model where no fundamental quantitative conceptualization could be applied to the design or where there was a lack of process data.

The formal discusser, Kosta (The Netherlands), pointed out that he was a consumer of this model, a design consulting engineer. He said the concept is useful, but the model is applicable only in the U.S.A. He objected to the lack of holistic approach and the total use of the suboptimization approach. He pointed out that the two networks for solids and liquids were unbalanced. He noted that no computer costs were given and no mention of whether the cost functions used were linear or hyperbolic. Iskoot (Sweden) also commented that, unlike a model for purification in a natural stream, this model could not be verified.

Randall (U.S.A.) answered the objections by saying that this was a first step and even with its inadequacies, the model was better than what was currently available. At the very least, its disjunctions indicated where future research efforts must go. He also stated that cost functions were linear, that the suboptimal approach was cheaper to execute than any holistic approach and permitted the inclusion of new technologies as they developed chronologically.

D. Paper No. C-53: "F Specific RNA Bacteriophages in Sewage: Methodology and Occurrence" by A. H. Havelaar, W. M. Hogeboom and R. Pot (The Netherlands)

The authors claimed that the presence of viruses in wastewaters is now more dangerous than the occurrence of bacteria. Direct analysis of enteric viruses is difficult for the following reasons: only a small number of specific viruses are detectable, and epidemiologically, the undetectable ones are the most important; the analytical detection methods for viruses are highly variable; sampling techniques must use large volumes in order to detect small numbers of viruses; and the use of tissue culture hosts is expensive. The use of a bacteriophage assay as an indicator of viral contamination is rather easy, however. The necessary criteria for use of a virus as an indicator are: the indicator must always be present where a pathogen is present, and absent when pathogens are absent; the number of indicators must be greater than the number of pathogens; the treatment effect on the indicator should be comparable to effects on the pathogen; and the indicator should be easy to isolate, identify and enumerate. F-specific phages were found to be excellent for this purpose. The most important characteristic is the mode of attack on the host bacterium F pili. The analytical procedure is simple, i.e., make a lawn and incubate; and inoculate and look for destruction of confluence.

These phages were found to be immune to chlorination and UV irradiation. For the analysis of wastewaters, one can use indigenous phages since they are present in sufficient concentrations. The presenting author, Havelaar (The Netherlands), described the development of their detection method for the purpose of identifying an indicator organism. This test procedure used S. typhimurium, F$^+$ strain as the host bacterium. He contended that this technique provided more explicit data than the E. Coli, C-strain test. The latter procedure is currently being considered for adoption as the host in a standard procedure.

The source of these F-specific phages measured in wastewaters is at present unknown. These phages have been detected in the feces of animals which have been bred in intensive agricultural feedlots, such as in the feces of pigs, broiler chickens, and sheep. The F-specific phages have not been found in human feces. Therefore, this type of indicator would not be indicative of human pollution. This test is practical for viral detection in drinking water supplies because F-specific viruses have not been detected in uncontaminated waters.

Hughes (New Zealand) posed a question concerning the required sample volume and appropriate concentration techniques for this virus. The author answered that one litre would be sufficient for concentration of enteric viruses since they die off quickly in drinking water reservoirs. Although somatic viruses die off less quickly than enteric viruses, if no virus is found in one litre, then the probability of the drinking water source being contaminated is very low. F-specific viruses have not been detected in uncontaminated reservoirs, so they could be used as an indicator in natural systems.

Shuval (Israel) congratulated the authors on their approach to the use of phages as indicators. He listed his questions, however, as follows: he is concerned about the use of an indicator which is absent from human feces, thereby relying on nonpoint source pollution input to a wastewater as a source of the indicator; he is also concerned about using a bacteriophage as an indicator when it could repopulate a system after disinfection if a bacterial host is present. How does bacteriophage behavior compare with enterovirus behavior in the environment?

Havelaar (The Netherlands) responded that in a reservoir, the absence of bacteriophage in human feces is an advantage. In recreational waters this fact is a disadvantage. The fact that phages can repopulate in a natural system is also an advantage since F-specific phages will not remultiply at temperatures below 30°C.

Cidar (Canada) questioned the resistance of F-specific phage compared to polio virus. The author responded that he had not, but at Delft, researchers had found significantly greater chlorination resistance than for other viruses. Kott (Israel) emphasized the fact that this indicator test is both cheap and fast. Lund (Denmark) objected to the lack of source from human feces. She stated that more investigation should be carried out on the resistance of this virus also. Havelaar (The Netherlands) agreed and described ongoing work toward these objectives.

E. Paper No. C-54: "Inactivation of Hepatitis A Virus, Other Enteric Viruses and Indicator Organisms in Water by Chlorination" by W. O. K. Grabow, P. Coubrough, C. Hilner and B. W. Bateman (South Africa)

The presenting author, Grabow (South Africa) began by comparing the chlorine resistance of Hepatitis A virus (strain MBB) to the following other organisms: Polio 2 (P2); Cox B5 (B5); Reo 3 (Reo); SA-11 Rotavirus (SA-11); Coliphage MS-2 (MS-2); Coliphage V1 (V1); *E. coli* (EC); *S. faecalis* (SF); and *M. fortutum* (MF). The Hepatitis A virus (HAV) was tested for indicator utility separately and in combination and was used from the seventh passage propagated in PLC/PRF/5, a human liver cell line. The MPN tube dilution assay was used and combined chlorine residuals were measured. Relative survivals of HAV were measured in tap water and humus tank effluent. Similar survivals were tested with free chlorine residual at pH value of 6, 8 and 10.

The conclusions drawn from these results were that in drinking water, conventional assays for poliovirus, reovirus and *E. coli* can be used as indicators of HAV survival. From the combined chlorine residual analysis, one could conclude that for wastewater detections, one must be very discriminating in choosing an indicator system. These experiments demonstrated the shortcomings of virus tests and the need for further work.

There was no formal discusser of this paper, but a lively discussion followed. Sobsey (U.S.A.) asked a procedural question concerning the MPN technique. In his work he had found that this technique misses low-level inoculations. The viral antigen procedure seemed to be more sensitive. Also the incubation time is 42 days and radioimmunoassay results are very accurate.

Eps (Sweden) commented that, in clean water, the analysis of organism resistance by combined chlorine analysis is poor. Sumitomo (Japan) stated that an indicator organism must be characterized by dose response data and data of minimal infectious dose permitted. Grabow (South Africa) agreed. Johnslee (United Kingdom) questioned the bold extrapolation of laboratory data to field application. He stated that groundwaters lack some indicators. While free of coliforms, those present are surprisingly resistant to chlorine. Grabow (South Africa) admitted that more work must be done before bold extrapolations to field data can be demonstrated, but so far the indications are good. For groundwaters with no apparent coliforms, large volumes of sample must be used for both viral and bacterial tests.

Shuval (Israel) objected to the above answer by reminding the audience that the standard procedure for coliform detection required 100 mL. He stated that even if the standard coliform test is passed, phage could still be present. Also, he claimed that often drinking water characteristics were similar to Grabow's wastewater, and, therefore, Grabow's results could be interpreted in reverse. Grabow (South Africa) responded by reiterating that this study was performed to determine an appropriate indicator organism and the assay therefore should fit the conditions. Hughes (New Zealand) mentioned that the test viruses were not complexed or attached. She asked whether a bacterial 'clump' with outer inactivated viruses and inner viable viruses could become infected. Grabow (South Africa) answered that no de-clumping was carried out in order to obtain the most conservative result. Kott (Israel) asked about the frequency of occurrence and quantitative assay for M. fortutum. Grabow (South Africa) replied that it was very frequent and could be assayed by membrane filtration, incubation, and acid-fast enumeration.

4. CRITIQUE OF SESSION

Paper Nos. C-50 and C-51 were on disinfection and described the development of nontraditional disinfection processes. They were both very general, measuring disinfectant doses and response. The first process was intended to disinfect drinking waters high in bromide content so as not to produce THM's or chlorite ion. The second process could be applied inexpensively to the disinfection of wastewaters. Both of these processes demonstrated promise, if further work (such as identifying oxidation products and determining their carcinogenicity) proved beneficial.

Paper No. C-52 was the only paper in the session utilizing theoretical aspects of any kind. The theory used was, indeed, only a vehicle for the model developed to otpimize wastewater treatment plant design costs and efficiencies. Also, this paper was a first effort in this regard and was criticized because of its lack of holistic approach. This writer agrees with Randall (U.S.A.) that a holistic approach to this optimization process would have been too costly to develop and operate. In addition, the combinatorial suboptimization approach indicated useful gaps in knowledge (theoretical or empirical) where future research efforts should be concentrated. These areas were especially prevalent in the sludge network of his model and included such topics as sludge rheological and thickening theory or data, sludge flocculation and dewatering theory or data, and sludge recylcing data.

Papers Nos. C-53 and C-54 served as the introductory papers to the special session on virology. Both aimed to test viruses as indicator organisms. There is no doubt that much research work must be carried out on viral assays and field detection. Each described candidate organism had advantages and disadvantages. The F-specific phage (Paper No. C-53) could be accurately enumerated by the technique developed by the authors, but it was not characteristic of human waste. Hepatitis A virus (Paper No. C-54), although a characteristic human virus, could not be accurately enumerated, so its value as an indicator organism could be questioned.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The first two papers in this Session (Paper Ncs. C-50 and C-51) concerned disinfection, and could be applied to areas of the U.S.A. with high ionic strength drinking waters and areas with high incident sunlight radiation. Appropriate geographical areas might include the 'sunbelt' states, particularly those of the Southwest. These papers dealt with new treatment technologies which should receive further attention; the first, because the U.S.A. must examine epidemiological impacts of carcinogenic pollutants in drinking water supplies and in treated drinking waters; the second, because the U.S.A. must look at innovative/alternative wastewater treatment processes, particularly for rural areas which cannot financially or technologically support a high-tech wastewater treatment plant.

The third paper (Paper No. C-52), on modeling wastewater treatment unit processes, was of importance for a number of reasons. Any attempt to rationally model wastewater treatment unit processes is fraught with inadequate fundamental bases; such inadequacies should point to the need for research and justify those needs. Any unified scientific, rational model should lead to optimal combinations of unit processes on the basis on efficiency (rather than on the basis of empirical observation) and cost considerations. These results should save everybody money. Finally, the costs to further refine this modeling approach are far less than the cost of building a treatment plant which does not work. This fact is most important for sludge treatment and disposal flows, a major component of the model presented by Randall (U.S.A.).

Paper Nos. C-53 and C-54 demonstrated the painstaking work that is necessary for virologists to gain further knowledge in this field. These virologists had conducted very elementary, narrowly-focused studies on virus detection and resistance to disinfection. The results are obviously a small part of the immense picture which is needed at this time.

1. SESSION

   A. Day: Wednesday, September 1, 1984
      Location: Hall 2
      Time: 1:30-5:25 p.m.

   B. Theme of Session: Virology and Particles in Surface Waters

2. REVIEWER

   A. Name: W. Wesley Eckenfelder, Jr.

   B. Position and Affiliation: Professor of Environmental Engineering, Vanderbilt University, Nashville, Tennessee (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-55: "Effects of Water Quality on Microporous Filter Methods for Enteric Virus Concentration" by M. D. Sobsey, T. Cromeans, A. R. Hickey, and J. S. Glass (U.S.A.)

This paper described the effectiveness of microporous filter methods for enteric virus concentration from water. In particular, the effect of humic or fulvic acid or bentonite clay particles on virus adsorption and recovery on two types of filters (electropositive Virosorb IMDS at pH 7.5 and electronegative Filterite filters at pH 3.5 with and without 5 mM $MgCl_2$) followed by elution with 0.3% beef extract in 50 mM glycine at pH 9.5 were evaluated. Natural particulates had little effect on virus concentration efficiencies. Soluble organic compounds reduced virus adsorption efficiencies, but the extent of interference varied with virus type and adsorption conditions. In particular, humic and fulvic acids caused appreciable reductions in poliovirus adsorption and recovery in both types of filters. Two viruses, polio virus and echovirus, showed improved adsorption to Filterite filters in the presence of high suspended solids but showed adsorption interference from soluble organics. The addition of $MgCl_2$ improved adsorption. The discussion by Leong (U.S.A.) and others agreed with the conclusions. The results of these investigations would indicate that virus recovery efficiencies employing these techniques are adversely influenced by water quality, particularly in the presence of high soluble organics and suspended solids. While further studies are needed to improve virus recovery efficiencies using microporous filter methods, the results of these investigations would indicate that current techniques should detect viral types even with a reduced recovery.

B. Paper No. C-56: "Factors Controlling the Survival of Viruses in Groundwater" by M. V. Yates and C. P. Gerba (U.S.A.)

This paper was directed toward defining the factors which control virus survival in ground water. The research involved collection of ground water samples from various locations in the U.S.A., innoculating them with coliphage MS-2 and determining the rate of virus inactivation with time at the temperature of the natural ground water. Variables investigated included pH, nitrates, ammonia, turbidity, TDS, calcium, magnesium and total hardness. Analysis of the results indicated that the significant variables in virus decay were temperature and calcium hardness. In general as viral adsorption to soil increased, viral survival increased. Viral survival decreased with increasing pH, resin extractable phosphorus, increasing temperature and aerobic soil organisms. Anaerobic organisms had no effect. This paper studied viral decay in several ground waters from Arizona, Wisconsin, New York and North Carolina, U.S.A. The specific results of this study indicated that persistence of viruses varied with location of sample, temperature and calcium hardness. A general conclusion is that MS-2 persists longer in ground water than in surface water. The practical significance of this research is the ability to predict the safe distances from septic tanks or wastewater land application areas for groundwater for potable consumption. The effects of calcium hardness and aggregation were questioned during the discussion as not being supported by the data.

C. Paper No. C-57: "Occurrence of Viruses in Treated Drinking Water in the United States" E. W. Akin (U.S.A.)

This paper discussed the occurrence of viruses in treated drinking water in the U.S.A. The paper reported results obtained in various studies over the past twelve years. The conclusion of the paper was that viral contamination of treated water from surface sources has not been demonstrated. Several previous studies in which viruses were identified were controversial due to suspected laboratory error. Viruses have been isolated in water supplies, but in cases in which treatment was not achieved, that would indicate that viruses probably do not occur frequently in treated drinking water at detectable levels. The studies did indicate, however, that adequate disinfection is essential in preventing virus transmission. One point that was made in the paper is that improved viral identification methodology will help focus epidemiological studies and research efforts on water systems. The discussion by Nupen (South Africa) and other comments clearly focused on methodology, namely that more work was required on virus recovery techniques to answer the question of whether viruses are present in treated waters.

D. Paper No. C-58: "Colloidal Stability of Particles in Lakes: Measurement and Significance" by W. Ali, C. R. O'Melia and J. K. Edzwald (U.S.A.)

This paper investigated the phenomena of natural particle stability in lake waters and developed a model to define this stability. Specifically, the reported research investigated the effects of solution characteristics on particle stability, defined a measurement of particle stability and considered the significance of particle stability on the transport of particle reactive pollutants in lakes. One of the primary factors developed in the paper is the "sticking factor" which defines the coagulation of the particles. Specifically, the sticking factor was defined as the ratio of collisions producing aggregates to the total number of collisions that occur by natural processes. Laboratory studies were conducted on several lake waters and reported in the paper. A general conclusion is that hard waters low in organic matter may be expected to contain unstable particles, be efficient coagulation basins, and be effective traps for particles, pollutants and nutrients. By contrast, soft waters high in organic matter may be expected to contain stable particles. The overall transport and fate of particles and associated pollutants in lakes depends upon areal hydraulic loading, particle stability and solid solute partitioning. All of these factors vary widely in lakes. A model was developed to provide a basis for predicting deposition and pollutant concentration in such systems. It was summarized that removal of particles in lakes occurs by coagulation which depends on the chemistry of the lake. Humic substances affect the stability of the particles. An interesting point was that nonbiodegradable organic carbon discharged from wastewater could affect the stability of particles in lakes.

Discussion by Downing (United Kingdom) questioned the hydrodynamic model and the interpretation relative to particle size. The response indicated that model sophistication can only come with time. The point was made that phosphorus provides a trigger for the generation of most particles due to algal interaction.

E. Paper No. C-59: "Sorption of Ammonia Nitrogen on River Borne Suspended Soils" by R. F. Wukasch and L. P. Moos (U.S.A.)

This paper attempted to relate an ammonia balance in a river between that fraction sorbed on suspended solids and that fraction remaining in solution. Experiments were conducted using Wabash River water with either a low or a high concentration of suspended solids. The results were correlated in accordance with a Langmuir adsorption isotherm. The conclusions drawn from these studies indicated that at low suspended solids levels (<65 mg/L), only about 4% of ammonia is sorbed, while at high suspended solids concentrations (>300 mg/L), sorption may be as high as 20%.

The methodology and the mathematical conclusions of this paper were thoroughly and severely criticized by Baumann (U.S.A.), and in the writer's opinion, with justification.

4. CRITIQUE OF SESSION

The papers reviewed varied in approach, topic and quality. Paper No. C-55 was a well-organized scientific study on an important analytical procedure and presents a significant advance on analytical procedures for viruses. It shows directions for future researchers to further refine methodology for quantitative virus identification. Paper No. C-56 was questionable and it tracked viral decay in various waters, but failed to model or quantify the results except in a general way. However, the complexity of the problem may render quantitative modeling impossible with the type and quantity of data available at this time. Paper No. C-57 is a compilation of statistical data and can only marginally be considered research. Paper No. C-58 provided a model for continuing research in this significant area. Paper No. C-59 is an example of conclusions drawn from incomplete and inaccurate research results.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The session on Virology provided significant information on measurement and quantification of viruses in waters. It should be noted that all the papers were presented by U.S.A. researchers and, therefore, reflect present U.S.A. activity. It was somewhat disappointing that relatively little was added to this work by discussion from researchers in other parts of the world. The session on particles in surface waters provided one outstanding contribution on colloidal stability of particles in lakes. The discussion identified work in other parts of the world and showed that research in this area is on an active path.

1. SESSION

   A. Day: Thursday, September 20, 1984
   Location: Hall 2
   Time: [illegible]00-9:35 a.m.

   B. Theme of Session: Cementation

2. REVIEWER

   A. Name: Edwin E. Herricks

   B. Position and Affiliation: Associate Professor of Environmental Biology, University of Illinois, Urbana, Illinois (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

Paper No. C-60: "Mechanism and Kinetics of Cementation Processes" by B. M. Khudenko (U.S.A.)

This paper reviewed development of a physical model of cementation processes, a spontaneous electrochemical reduction of electropositive species by electronegative metals. Existing models depend on first-order rate equations, but empirical observations have identified significant differences between theory and observations.

The proposed model included consideration of both diffusion and migration. The major parameters considered by the model include the concentration of the electropositive (nobel) species, pH, surface of the sacrificial metal, and mixing rate. The model approached diffusion processes using a "push-pull" mechanism which balances charges in the galvanic cell between the sacrificial metal and the bulk solution. Migration kinetics in the model were treated as being dependent on the rate of transport processes at the solid-liquid interface, the electric current in the galvanic cell, and aspects of the conjugate oxidation of the sacrificial metal and reduction of noble species. The model fitted well with empirical data and provided insight into the nature of the reduction of Cr(VI) by iron.

The author suggested that the model effectively dealt with the effects of stoichiometry, speciation, and parallel reactions in the cementation process. He suggested that the model assists in a better understanding of cementation processes and will assist in improving process designs which depend on cementation.

4. CRITIQUE OF SESSION

The single paper was directed to issues of synthesis through modeling applications rather than presenting new empirical data. The model has been tested, but a more complete experimental analysis of model validity would be necessary before general application.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The model presented provides a basis for improvement of metals removal processes. The removal of heavy metals from wastewaters and the extraction of metals from sludges may be facilitated by a better understanding of the removal processes provided by the model. The model also provides a basis for better definition of the operational conditions which can optimize metals removal.

1. SESSION

   A. Day: Thursday, September 20, 1984
      Location: Hall 2
      Time: 9:35-10:10 a.m.

   B. Theme of Session: Eutrophication

2. REVIEWER

   A. Name: Edwin E. Herricks

   B. Position and
      Affiliation: Associate Professor of Environmental Biology, University of Illinois, Urbana, Illinois (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-61: "Phosphorus, Nitrogen and Chlorophyll-A Concentrations in a Typical Dutch Polder Lake Tjeukemmer, In Relation to its Water Regime Between 1968 and 1982" by H. De Hann and J. R. Moed (The Netherlands)

This paper, presented by De Hann (The Netherlands), analyzed fifteen years of water quality data for the largest polder lake in Friesland, a northern province of The Netherlands, to produce a statistically simple model which would assist in the management of lake water quality. Tjeukemeer, the polder lake, is a part of an interconnected land drainage system subject to seasonal changes in water source and quality. The lake receives humic-laden agricultural drainage from the polders in the winter and chloride-rich Ijsselmeer water in the summer. The source of Ijsselmeer water is the Rhine River. The managed hydraulic regime of Tjeukemeer allowed identification of relationships between the quantity and source of influent water and eventual water quality in this managed water resource system.

In winter when there is a surplus of water in the polders, the lake water quality is dominated by agricultural runoff. The polder drainage is humic and fulvic acid rich with high nitrogen and phosphorus concentrations. Ijsselmeer water is not as strongly colored, low in nutrients, but high in chloride concentration. An examination of the historical data using correlation analyses, identified good correlations between nutrients and chloride, reflecting the dominant source of lake inflow. This correlation provided the basis for developing a simple correlation model which provided predictions of Tjeukemeer water quality based on inflow and outflow conditions. Nutrient concentrations were also related to chlorophyl-a concentrations, an indicator of phytoplankton abundance. During the growing season, the phytoplankton in Tjeukemeer is dominated by blue-green algae, predominantly *Oscillatoria agardhii*. The authors suggested that nitrogen may be more limiting than phosphorus in Tjeukemeer, although other factors such as light may play a major role in limiting algae growth. The mean concentrations of nitrogen consistently exceeded Ministry for Transport and Public Works standards while winter concentrations of phosphorus and recent summer concentrations of chlorophyl-a exceeded standards. The paper suggested that effective management will require identification of the factors limiting algae growth. Limiting factors would need to be determined experimentally which would required additional research.

The concept of nutrient limitation was questioned by Martins (Portugal) resulting in a clarification of the fact that the major nutrient relationships were suggested rather than verified. The fact that a rather simple model was used to provide a basis for the prediction of nutrient loading effects is controversial. The application of simplified models may be inappropriate in complex situations, and the basis for management should be analyses which are based on more than first-order correlations. The authors agreed with these comments and noted that further studies, including the bioassays necessary to confirm phytoplankton growth limitations, were essential for use in resource management.

B. Paper No. C-62: "The Role of Phytoplankton in the Dissolved Oxygen Budget of a Stratified Estuary" by P. G. Soulsby, M. Mollowney, G. Marsh and D. Lowthion (United Kingdom)

This paper, presented by Soulsby (United Kingdom), combined a two-dimensional hydrodynamic model with a dissolved oxygen prediction model to provide the basis for describing oxygen conditions in the Test estuary of Southern England. The modeling program was intended to predict the oxygen balance as it might be affected by increased effluent loading, increased water abstraction, the addition of cooling water, and as might be affected by dredging. Dissolved oxygen maintenance in the estuary is necessary to allow salmon migration and maintain hard shell clam beds. The hydrodynamic model is a multi-layer, two-dimensional, multiple cell approximation of mixing in the estuary used to predict water circulation and vertical mixing. The dissolved oxygen model evaluated oxygen flux due to oxidation of carbonaceous and nitrogenous material in each cell. This analysis also reflected sediment oxygen demand and surface reaeration. As a component of the dissolved oxygen model, a photosynthesis sub-model was developed which estimated the effects of photosynthesis based on nitrogen concentration and observed chlorophyl concentrations.

In testing the model, the authors noted that model predictions of dissolved oxygen produced a poor fit to actual observations even though the hydrodynamic and chemical models were well verified. They concluded that the ciliate *Mesodinium rubrum* (Lohmann) was the cause of the observed anomalies, but the mechanism was not simple. The ciliate migrates between the surface and the bottom of the estuary. During bloom conditions, surface waters, were saturated with dissolved oxygen while bottom waters where the major night time respiratory demand occurs, oxygen was depleted. The model was modified to predict oxygen concentration based on oxidation of organic input, the breakdown of chlorophyl and chlorophyl respiration allowing prediction of dissolved oxygen throughout the water column.

The utility of combining field observations with mathematical simulations was well demonstrated in this paper. The paper also demonstrated that the application of standard modeling techniques in an estuary with complex hydrodynamic, chemical and biological interactions will need modification to fit empirical observations and account for significant biological processes. Questions raised by Holmes (Hong Kong) addressed the importance of ecological factors, such as grazing, on model accuracy. The factors limiting phytoplankton growth still must be identified to make the model suitable for management of the multiple uses identified for the estuary.

C. Paper No. C-63: "Restoration of Lake Veluwe, The Netherlands, by Reduction of Phosphorus Loading and Flushing" by S. H. Hosper (The Netherlands)

This paper reviewed the effects of remedial nutrient control techniques used in the management of the hypertrophic Lake Veluwe. Lake Veluwe is shallow with a mean depth of 1.28 m. The lake was constructed in 1956 with significant water quality deterioration occurring in the late 1960's. The nutrient control techniques initiated in 1979 included effluent phosphorus reduction at two sewage treatment plants, and the use of excess polder water pumped back to the lake to increase flushing rates.

The author suggested that reducing external phosphorus loading will not restore lake water quality because of significant sediment phosphorus concentrations. The intent of the increased flushing is to break the cycle of sediment phosphorus release mediated by the blue-green alga *Oscillatoria agardhii*. The objective was to intensify flushing during the winter months with water containing a low concentration of phosphorus. This flushing reduced phosphorus concentration and decreased phytoplankton biomass producing a reduction in sediment phosphorus release.

The management efforts appeared to be partially successful. The pronounced cycling of phosphorus between winter and summer was broken, and total phosphorus and ortho-phosphorus concentrations decreased. Nitrogen concentrations still display seasonal periodicity. In general, chlorophyl concentrations decreased due to flushing and external phosphorus control, but biovolume measures did not decrease, indicating an adaption of *O. agardhii* to the conditions modified by management procedures. The final result of these management techniques is still uncertain.

Discussion by Hogendoorn (The Netherlands) identified high internal phosphorus loading as a continuing problem which may require implementation of other remedial measures for lake restoration. Thus, although water quality appears to comply with standards, the dominance of *O. agardhii* indicates reduced management success.

D. Paper No. C-64: "Water Quality Control of the Andelse Maas Basin, The Netherlands, by Iron Dosing" by A. C. Hoekstra and K. D. Maiwald (The Netherlands)

This paper, presented by Maiwald (The Netherlands), described a chemical management technique to reduce phosphorus and control algae growth in the Andelse Maas Basin which provides the major water source for The Hague. The Andelse Maas Basin was a connection between the river Meuse and the river Waal and the chemical dosing has been underway since 1976. The chemical used was iron sulfate which is added to river flow soon after water is withdrawn from the river Meuse. Tidal effects still occurred in the Andelse Maas Basin.

The results of the iron sulfate dosing included a decrease in the phosphorus content of Andelse Maas Basin waters and algae biomass is maintained below the acceptable limit of 25 to 50 µg/L of chlorophyl-a. To more effectively control iron sulfate dosing, the authors developed a model based on the interaction between phytoplankton and nutrients coupled with a flow model. The phytoplankton/nutrient model is quite complex requiring estimation of forcing functions as well as species specific nutrient relationships. Model calibrations were made under different iron sulfate loadings, and the model was verified during periods when chemical dosing was suspended. The model was used to optimize iron dosing and evaluate the consequences of termination of chemical treatment.

The management approach reviewed in this paper is large scale, *in situ* chemical treatment. The unique situation of relatively uniform channel dimensions, low flow, and increased contact time due to tidal influences makes the Andelse Maas Basin management a valuable lesson in nutrient and biomass management in eutrophic systems. The development and application of a rather complex model to evaluate the consequences of management alternatives further refines the management capabilities when critical water supply issues are present.

4. CRITIQUE OF SESSION

This group of papers, all dealing with analysis and management of eutrophic systems, have the common thread of topic, but different approaches to management. Paper Nos. C-61 and C-62 approached management through description of ambient conditions followed by development of models which allow analysis of relationships and prediction of conditions. Paper Nos. C-63 and C-64 reviewed physical management techniques directed to nutrient reduction or control. In general, the models are flawed because they cannot account for the natural complexity in eutrophic systems, but they do provide a basis for quantitative decision making. The remedial management techniques represent large-scale pumping or chemical dosing which provide for little long-term improvement, but do provide effective short-term control of nuisance conditions. In all papers, notice was given to control of nutrient addition, but dealing with degraded ecosystems is a struggle.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

Lake management programs have developed under Section 314 of the Clean Water Act. A number of remedial programs have been instituted, and lake management and restoration efforts have been successful in some cases. This group of papers identified additional management approaches which can be applied when a clear mandate is given to provide acceptable water quality in eutrophic systems. The model developed for the Test estuary identified the importance of the inclusion of biological parameters in models traditionally used for wasteload allocation (Paper No. C-62). The models applied to eutrophic systems, whether simple correlation models (Paper No. C-61) or complex models relating phytoplankton and nutrients (Paper No. C-64), demonstrated the utility of these approaches as well as the limitations of models when ambient conditions may vary.

1. SESSION

   A. Day: Thursday, September 20, 1984
      Location: Hall 2
      Time: 2:00-4:20 p.m.

   B. Theme of Session: Production of Plants and Algae from Wastewater

2. REVIEWER

   A. Name: Alan H. Molof

   B. Position and Affiliation: Associate Professor of Civil and Environmental Engineering, Polytechnic Institute of New York, Brooklyn, New York (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-65: "Treatment of Agro-Industrial Wastes Using Water Hyacinth," by C. K. John (Malaysia)

Industrial wastewater from processing of natural rubber and palm oil is biologically degradable in both anaerobic and facultative lagoons. Natural rubber processing yields a wastewater with a BOD of 1450 mg/L, a COD of 2520 mg/L, a suspended solids of 920 mg/L and a total nitrogen of 165 mg/L. Palm oil processing yields a wastewater BOD of 25,000 mg/L, a COD of 53,630 mg/L, a suspended solids of 19,020 mg/L and a total nitrogen of 770 mg/L. Natural rubber effluents were treated with water hyacinths at hydraulic retention times (HRT) of two to 15 days. A HRT of ten days produced BOD, COD, SS, and total nitrogen removals of 85%, 80%, 80% and 53%, respectively. Performance was improved at a HRT of 15 days. Palm oil mill effluent from a primary anaerobic lagoon was treated at a HRT of 10 to 25 days. The best treatment values were achieved at an HRT of 25 days, where BOD, COD, SS and total nitrogen removals were 96.4%, 87.3%, 96.1%, and 77.2%, respectively.

Natural rubber factories with existing lagoon systems were selected for plant-scale trials at HRT values of 12-15 days. Water hyacinths were grown in a second pond, following an anaerobic lagoon. The data comparing treatment with and without water hyacinths showed that the hyacinths had a beneficial effect.

Harvesting was done on a systematic basis with one third of the material being harvested every two weeks.

Hughes (New Zealand) stated that although the topic was of considerable interest, the process was not in use in New Zealand. She indicated that they conducted studies in which a secondary sewage effluent passed through a raceway containing *Gylceria maxima*, before discharge into a eutrophic lake. In similar experiments, they achieved reductions in nitrogen, phosphorus and coliform. Sedimentation problems occurred at the end of the raceway outlet where plants were not actively growing, the effluent flowed under the plants and limited nutrient removal was achieved.

Hughes (New Zealand) posed the following questions: (1) Is finding a noxious weed a problem? (2) Did the experiments have control tanks with which the water hyacinth tanks could be compared? (3) Did sedimentation take place in the lagoon? and (4) What was the effect of low DO in the lagoon?

The author responded as follows: (1) There was no attempt to grow and cultivate water hyacinth so there was no noxious weed problem. The attempt was to grow the water hyacinth in an existing system to increase treatment efficiency. (2) Comparison of treatment with and without the water hyacinth was shown with the commercial lagoon system in which the water hyacinth showed significant improvement. The tank system exhibited similar results. (3) Sedimentation was not a noticeable problem since systematic harvesting was used. (4) The commercial tanks were 1.2 m deep, while the laboratory tanks were 0.46 m deep. Since it was found that 0.6 m was the best depth, deeper lagoons will be less efficient.

Colbe (South Africa) commented that with a two-week harvesting schedule with one-third removal, the microorganism/food ratio must change rather drastically. He asked if the harvesting frequency was optimized with respect to treatment efficiency. John (Malaysia) replied that they did not study the harvest frequency but that, after harvesting, the water hyacinths were redistributed over the whole area.

Neuvich (Portugal) commented that water hyacinths have been used in the U.S.A. for nutrient removal after tertiary treatment, and he asked if the process could be used for domestic wasterwater. John (Malaysia) indicated that the work in the U.S.A. was basically with domestic wastewater. He stated that the process was used for the natural rubber wastewater with a BOD of 1400 mg/L without pretreatment, while the palm oil wastewater with a BOD of 25,000 mg/L required pretreatment.

Haben (Austria) asked if the micoorganisms or the water hyacinths were responsible for BOD and nutrient removal. John (Malaysia) replied that both were responsible. However, the doubling time of the hyacinth was 10-14 days in terms of dry weight, indicating significant growth and therefore removal of nutrients.

B. Paper No. C-66: "The Selective Cultivation of Easily Harvestable Algae Using Crossflow-Microscreening" by W. A. Pretorius and L. C. Hensman (South Africa)

Pretorius (South Africa) stated that oxidation ponds are not widely used in South Africa because they do not meet effluent regulations. However, the great amount of sun makes their use very attractive, if the removal of algae can be done at a reasonable cost. The approach used in this regard was based on combining removal of algae with selective cultivation of an organism which can be easily harvested. A simple approach of screening was used rather than more complex methods of selective cultivation.

There were four reactors, each with a different type of innoculum. In the initial run using a 50- m screen, plugging occurred in three days, caused by a calcium precipitate formed at high pH. Similarly an 80-μm screen plugged quickly from clumps of diatoms. Increasing the size of the screen to 200-μm worked well for months without problems. Even though there were four different inoculums, final results indicated the same organism persisted in all cases, proving that the sytem was quite reliable in selecting a specific group of organisms.

A series was done with oval channel reactors using a 200-μm screen. The HRT and the algae sludge age were controlled independently. The concentration of the algae harvested was about 8% (total solids), and vibrating screens were used to thicken the algal sludge.

The nominated discusser, Ives (United Kingdom), stated that the paper solved two problems in algae culture management: selection of algal species, and maintenance of a continuous culture at a maximum growth rate. Ives (United Kingdom) inquired as to the influence of volume, flow rate, surface area, paddle mixer and degree of turbulence on scale-up of the reactor. Ives (United Kingdom) indicated that microscreen rotary disks have been used a long time for algae separation. Long-term clogging due to slime growth has been solved by a combination of washing jets and ultraviolet-lamp radiation. In reference to a comment by the author on cultivation of Spirilina for its protein content, Ives (United Kingdom) indicated some industrial cultivation is done in spiral shaped ponds similar to carrousel oxidation ditches. Spirilina has been traditionally grown for cattle feed in Chad, Africa and more recently, cultivation of algae for protein on an industrial scale has taken place in southern Italy. The experimental ponds in Italy were similar to those of the author but on a larger scale.

Ives (United Kingdom) stated that the agglomeration of diatoms up to a size approaching fine sand and flocculation of Oscillatoria, as observed by Pretorius (South Africa), raised interesting questions concerning the causes of these phenomena. He inquired if flocculation was due to age of the cultures, metabolic polymers, or associated bacteria.

Rivas (Venezuela) commented on his work with raw sewage chlorination after microscreening where the screen plugged from oil and grease. He asked if the author had any similar experience with oil and grease.

Grieves (United Kingdom) commented on the use of the term microscreen or microstrainer. He indicated the equipment described by the author should be called a microstrainer since it was a rotating drum screen and material was retained on the screen and removed by water jets when the drum reaches top center. He stated that the use of "micro" is indicative of pore openings of 20- to 100-μm for filter cloths and use of the term "microscreen" for a unit with pore openings of 200-μm was unjustified. He requested the author to comment on cross flow versus noncross flow screens. He commented on scale-up economics in which it was stated that a moving screen would be better in performance and cost.

Goodinal (South Africa) stated the author has done subsequent work and requested information on the quality of the effluent.

In response to the comments and questions posed by Ives (United Kingdom), Pretorius (South Africa) indicated that the reported research was preliminary and was being expanded to a 5.5 x 10^4 m^3 plant operating on a trickling filter effluent. He had not evaluated size and flow rate any further than an average flow rate of 50 m^3/m^2-h. They do not intend to use mixer energy to keep algae in suspension and clear the screen with the same energy. Since mixing algae is easy, they now will use a square pond with a movable mixer going up and down the pond. Bacterial growth on the screens was a problem. However, using a secondary effluent, oxygen production by algae converts most organics to a non-degradable form, and it was observed that there was no plugging in the four months of operation with a 200-μm screen. If a larger screen is used, the effluent will be more turbid.

If the lagoon is too deep, there will be limited growth due to the shading effect. From present work, the light penetration is far better in the suspended growth system because of big flocs than in a unicellular algae system.

With regard to effluent quality, the suspended solids concentration in the effluent was seldom greater than 10 mg/L and was attributable to diatoms. Diatom clumps were the only product if the HRT was four to five hours. There is no problem cultivating the diatoms, since with a growth rate of 21 d^{-1}, it is one of the fastest growing photosynthetic organisms.

As to microscreening and microstraining, the author has no preference. The use of "micro" was based on the beginning screens which were around 50-μm and continuing the same terminology for the larger screens. Since the work was with a tertiary effluent, the author had no experience with oil and grease.

Duvin (South Africa) asked if the process could be used for carbon stabilization by biological treatment. The author replied that they are interested in separating the various biological phases occurring in the oxidation pond and are also interested in combining this with a bacterial system separated by a screen. They are now growing bacteria on screens, since clogging here is a much bigger problem, and are working on keeping the screens clean. Preliminary results show excellent flocculation of bacteria at a sludge age of three to four hours, producing a reasonably clean effluent.

C. __Paper No. C-67__: "Waste Water Recycling by Duckweed for Protein Production and Effluent Renovation" by G. Oron (Israel), L. R. Wildschut (The Netherlands) and D. Porath (Israel)

The author compared conventional wastewater treatment as equipment intensive and oxidation ponds as land intensive. In oxidation ponds, there are two types of aquatic plants that have been used: water hyacinth and duckweed. Because of numerous problems with hyacinths, the authors used duckweed. Duckweed is a floating aquatic plant which grows on many canals in The Netherlands and is very easy to harvest by skimming. Plant generation time is two days and has a growth rate of 0.3 d^{-1}. The protein content of 30-37% is less than that of algae (50%) and more than that of the water hyacinth (15%). Duckweed amino acids include lysine and methanine which are twice the concentration of other plants, increasing the nutritional value of duckweed. In addition, ammonia nitrogen is converted by duckweed to plant protein, as with algae and is more efficient in the nitrogen cycle.

The aim of the work was to use three species of duckweed to produce protein for animal feed and water reclamation for land irrigation. Loadings were based on a COD/NH_4^+ ratio at hydraulic detention times of 10 and 20 days. A mini-pond held 40L and had an area of 0.2 m^2 and a depth of 20 cm. A control pond had a carbon-free feed composed of an artificial fertilizer. DO was affected adversely by the COD concentration in the feed. __Wolffia arrhiza__ died out and algae took over. Reinnoculation was not successful. Subsequent runs were run with two species, __Lemma gibba__ and __Spirodela polyrrhiza__.

Dry yield was affected by ammonia concentration. At an ammonia concentration of 50 mg/L, the yield was 10 g/m^2-d and was reduced as ammonia concentration was increased to 200 mg/L. There were similar results for both species for the two HRT's and two ammonia levels. The yield was an inverse function of ammonia concentration while protein content was a direct function of ammonia concentration. Water losses due to evaporation and evapotranspiration could not be separated because the plant floated. Less evaporation occurred in the duckweed ponds than in the free surface ponds.

The nominated discusser, Tarinon (South Africa), commented on the amount of work done with duckweed as a feed source for animals and poultry. He mentioned that in rural Czechoslovakia, ponds between houses are used to grow duckweed for a protein source. The discusser believed that treatment with a dual use of growing protein and cleaning up the water was preferred.

Duckweed approaches algae in productivity, and the discusser indicated that he had information on protein content and the amino acid spectra. There is a great need for basic biological information such as a suitable growth kinetic models for these plants. The nominated discusser referred to his work on growth kinetics for the plant, *Sarvino malesta* where the maximum growth rate was a function of temperature while the specific growth rate was a function of both temperature and methane. By looking at other kinetic models, it will provide a better basis for designing systems and evaluating at the pilot plant level. At the second level, there is a need to know much more of the engineering aspects of aquatic plant systems such as harvesting, production, drying, and safeguarding the product.

Myron (South Africa) stated that the work was of great interest, since they had a recent application in South Africa. An existing activated sludge oxidation ditch was overloaded. A primary oxidation pond was built to relieve the overload. Now, the oxidation ponds oxidized the carbon while the oxidation ditch supplied the nitrogen removal. The effluent from the ditch goes to maturation ponds which have a cover of *Lemna*. The algae from the pond and the ditch are surpressed in the maturation pond since the *Lemna* growth prevented light penetration. In winter, the *Lemna* growth on the surface has been great. He asked what would be expected from seasonal variation.

Addin (Israel) stated that harvesting of algae has been done for a long period in South Africa, Israel and elsewhere, yet there has not been any industrial applications. The prevailing reason has been cost. The author was asked if his type of harvesting would result in improvements. The author stated that they are continuing to examine the biological aspects of the plant, especially the mechanism of preferential uptake of ammonia. For the engineering aspects, they are continuing research on *Lemna* treatment with and without settling and with various HRTs. The experiments were done in a relatively dry area. In the summer, the mean temperature was 25-28°C, solar radiation was 600 cal/cm^2-d, and duckweed gave very good yields. They did not yet try with domestic wastewater in a cooler condition. In winter they have significant variation between day and night. Their experiments in winter were with fish wastewater, not domestic wastewater. The results were good and therefore seasonal conditions in this case were minimal.

The technology of harvesting is well known, but the economics is questionable. Duckweed can be very easily harvested by simple skimming and drying. It can also be used immediately as fish food since fish like floating food. The lack of a need to dry the plant made fish produciton in tanks more economical.

D. Paper No. C-68: "A Potential Treatment Alternative for Swine Wastewater in the Tropics" by P. Y. Yang and S. Y. Nagano (U.S.A.)

The author stated that the proposed treatment was not a solution to all hog waste problems in the tropics and, and it would depend on climate, location, and environmental and social factors. The reason for starting the project was that 70% of the hog producers were in the Honolulu area where land is in short supply, and there is population encroachment from the city.

The suggested process starts with the wastes going to the anaerobic digester. Digested sludge is dewatered, dehydrated and used as a soil conditioner, fertilizer, and animal feed. Digester supernatant liquor and dewatered liquor are sent to an existing anaerobic lagoon. If no lagoon is existing, the supernatant goes to an algae biomass raceway. The resulting effluent from the raceway can go to a sewer, to flush the pig pens, or to aquaculture systems. The biogas is used to provide energy for the processing systems.

The pilot plant for pig-pen waste consists of a holding tank which feeds the anaerobic digester. The digester supernatant as well as the holding tank supernatant go to the algae biomass raceway. The digester sludge is recycled to increase treatment efficiency and reduce the digester volume. The system was operated at HRT values of nine, six, four, two and one and one-half days, respectively. Formerly, with no sludge recycle, it took 15 days to achieve optimum gas production. The HRT was reduced to determine the total volatile solid (TVS) loading necessary for maximum performance which ranged from 0.76 to 5.2 g TVS/L-d. The best gas yield was between 2.76 and 4.6 g/L-d and is the loading range that should be used for the sludge digestion. The critical loading for gas production was about 4 g/L-d.

The second pilot plant process, the algae biomass raceway, was aerobic and is similar to an activated algae process. The oxidation pond is 1-m deep with mixing and aeration provided by a perforated disk operating at 87.5 rpm. Oxygen transfer characteristics of the system were determined before the biological input was 39 kg/d. The raceway was capable of handling the incoming total COD at 10 hours aeration/day and the incoming soluble COD at eight hours/day.

With continuous aeration, pH dropped, and nitrite and nitrate nitrogen accumulated. At 12 hours aeration/d, the results were satisfactory. At 24 hours, the total output of COD was only 6%; at 12 hours, it was 17%; and at six hours, it was 36%. The sludge produced settled very well with the SVI being less than 100 mL/g.

Comparison of the energy requirements of the algae biomass raceway system to other aerobic systems such as oxidation ponds and ditches showed that the algae biomass raceway used less energy. The author stated that the energy consumption was 20 times better. The author concluded that the results of testing the anaerobic digestion-algae biomass raceway system for hog waste treatment made him more confident to go further in suggesting this system for the tropics.

The nominated discusser, Ordendahl (South Africa) stated that the swine waste problem occurs worldwide and is a growing problem. The wastes are produced at the rate of 33 kg/kg-y, on an animal body-mass basis. His comments were mainly on economic feasibility of the integrated process: the objective was to develop a low cost and effective process, yet no economic evalution was presented; comment on mechanical problems connected with pumping, gas leakage, flame traps, and corrosion; generation of electricity from biogas has not been found to be economical. Have the authors made an economic assessment of this aspect? What monitoring control system will be recommended to the farmer who has no expert backup?

In the motivation for this project, the atuhors claimed a number of disadvantages for the anaerobic lagoon system which is at present the most common and easiest treatment system practiced by the swine producers in Hawaii. The nominated discusser commented on the authors' list of disadvantages. 1) No by-product recovery: What about a storage of liquid wastes and application of nutrient-rich wastewater when required to reduce the moisture requirement of crops? 2) Periodic maintenance to remove settled sludge: If straw or saw dust is screened out of the lagoon influent, the lagoon may not be desludged for eight to ten years or even longer. 3) Possible odor problems and ground water contamination: Odor problems will not exist provided that: a) the lagoon volume is large enough, at least at 0.1 m^3/kg (live body mass); b) lagoons should be loaded frequently, at least once per day; c) antibiotics and disinfectants should be kept out of the lagoon influent; d) should H_2S smell exist or develop, relief can be achieved by adding iron powder or liquid ferric chloride which will precipiate sulfide as an insoluble metal sulfide; 4) Large land requirements: This requirement can be reduced by using deep lagoons 6 m or even deeper instead of the existing use of 2 m.

The author answered the nominated discusser. 1) Before initiating the first anaerobic system, an economic analysis was done for the digestion only. The results showed a two-year payback period. Any overall economics will depend on the system developed. 2) In Hawaii, there are three pilot plants with 20 m^3 digesters. One chicken producer has a 300 m^3 operating digester. If these were not economical, the producers would not use them. There is a reason why digesters can be operated because they are simple in operation and low cost. To build an oxidation ditch for 2,000 pigs with one pig at 45 kg, the cost was $200,000. This does not include operation. One kg BOD_5 removed requires 5.6 kwh. 3) There is no study on electrical generation. Some 70% of the energy from biogas would be wasted if not recovered. Electricity from biogas may not be practical. However, it should be recovered for heat. 4) A simple gas meter was set up to monitor the system. If something was wrong, the gas would decrease. 5) Anaerobic lagoons have been used in Hawaii for many years. At present, there are problems such as rising sludge. The U.S. Soil Conservation Service gave $3,500 to a hog producer to consult on its anaerobic lagoon system. Now, after the year study, 100% of the Soil Conservation Service agree in addition to anaerobic lagoon systems, they would supply some money to the author for setting up a digester at one raceway system. The author stated that anaerobic lagoons are not bad. Their use depends on location. If in a remote area, that is fine, but not near a city like Honolulu.

4. CRITIQUE OF SESSION

The interest of workers in the aquatic plant treatment area was evidenced by their interest in this session. The aquatic plants used in wastewater treatment include algae, water hyacinth and duckweed. Two of the four papers in this session had recent continuing work which added to the value of the presented paper.

The first paper, Paper No. C-65, proposed water hyacinth as the final step in the treatment process for rubber plant and palm oil wastewater. Harvesting was done with manual labor.

Paper No. C-66 was highly innovative in proposing a process using a crossflow screen to selectively grow an easily harvestable algae. Although the algae could be used as an animal feed, the author only concentrated on waste treatment. The work after the paper was prepared concerned combining bacterial and algae. The work is in the beginning stage of development.

Paper No. C-67 concluded that duckweed should be used instead of algae or water hyacinth. The paper described the use of duckweed as a treatment method and as a source of irrigation water and animal feed. Economics of fish farming were improved by feeding undried duckweed as fish food. Loss of water from the lagoon with duckweed was less than an equal area of free surface. Continuing work since the paper was submitted increased their confidence in the process and its possibilities. No data was supplied to support their increased confidence.

Paper No. C-68 described a treatment system for swine wastes by anaerobic digestion followed by an algal-biomass raceway. Energy benefits were claimed by the authors. The work resulted from the encroachment of Honolulu, Hawaii on the swine farms with their anaerobic lagoons. Although the objective of the study was to develop a low cost project, no cost figures were provided.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

Paper No. C-67 was from Israel where there is a water shortage. This work combining waste treatment, irrigation water and animal feed could relate to the Southwest of the U.S.A. where there is a water shortage. Paper No. C-66 (U.S.A.) introduced new technology on algae growth and harvesting.

1. SESSION

   A. Day: Monday, September 17, 1984
      Location: Hall 3
      Time: 2:00-5:25 p.m.

   B. Theme of Session: Analysis of Water and Wastewater and Biological Water Quality Assessment

2. REVIEWER

   A. Name: Lawrence H. Keith

   B. Position and Affiliation: Chemistry Development, Radian Corporation, Austin, Texas (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-69: "The Application of Information about Conductivity in the Computing of Ion Concentrations, Illustrated by Certain Surface Waters Situated in Lower Saxony" by W. Walther, M. Gorsler, J. Poltz and D. Bock (Federal Republic of Germany)

This paper described methods of estimating concentrations of the most important ions in water by using mathematical models and data from conductivity and pH measurements. Two illustrations were presented: one was a river water and the second was a shallow eutrophic lake.

Much of the paper was devoted to describing the theory of conductivity and its application to these types of estimations. Large amounts of data and equations are provided. This work can be considered to be the first case in which the theory of Onsager and Fouss has been applied and tested with data from large inland water systems. Since the equations used in this model were derived from data of actual chemical analyses, their accuracy is qualified by the accuracy and reliability of these analyses as well as by the limitations of the mathematical model used. However, the investigations presented in this paper indicated that it is possible to compute the concentrations of calcium, magnesium, sodium, potassium, bicarbonate, sulfate and chloride ions using the model these authors have developed with only conductivity and pH data.

It is important also to note that the equations for calculating the ion concentrations are specific for each water system and even for each part of it. Therefore, the models are valid only so long as the infrastructure of the particular catchment area being modeled is not changed. It is important, therefore, to frequently check the equations used against actual chemical analyses to verify that no significant changes have occurred.

Van Vliet (South Africa) pointed out that both the traditional regression equations and the author's experimental model gave closely agreeing results. The author responded that they have been able to cover all of the ions they are interested in with the theoretical model, whereas this is not possible with the regression equations. Nevertheless, in practice the regression equations will still be frequently used because of the simplicity of using this approach versus the complexity of using the model presented in this paper.

B. Paper No. C-70: "Hazardous Substances in Waste Water" by A. B. van Luin and W. van Starkenburg (The Netherlands)

This paper presented a survey of the presence of polynuclear aromatic hydrocarbons and chlorinated phenols and hydrocarbons in a series of influents, effluents and sludges from municipal waste water treatment plants and a variety of industries in The Netherlands. From this survey it was concluded that volatile chlorinated hydrocarbons in sewage originate mainly from industrial discharges and that many of the other compounds studied are at low and constant background levels in municipal sewage and in many industrial wastewaters. PCBs and fluoranthene were always detected in sewage sludge.

By comparing the concentrations of various compounds in the influents and effluents of the municipal treatment plants, the overall removal efficiencies were calculated. The most important conclusions from this exercise was the determination that PCBs, polycyclic aromatic hydrocarbons and hexachlorobenzene are efficiently removed (85-95%), hexachlorocyclohexanes and volatile chlorinated hydrocarbons are removed with moderate success (40-90%), and that chlorophenols are removed with the least efficiency (20-40%). These results do not seem to compare trendwise with other published data.

Many questions concerning the validity of the data presented were raised by Keith (U.S.A.). No details were presented for any of the methodologies used and only a single analytical reference (for analysis of PCBs) was listed. Likewise, no information was presented on the sampling methods used, the sample concentration and cleanup methods, blanks, calibration curves, confidence levels or the variability of the data. The author was unable to respond to questions involving quality assurance and quality control aspects.

A participant from Israel questioned the reason for the large fluctuations observed with the halomethane data, but the author was unable to explain them. It was discovered, furthermore, that none of the qualitative or quantitative results presented in this paper were confirmed by gas chromatographic-mass spectrometric (GC-MS) analysis.

Since the detectors used for analysis (fluorescence and electron capture) are nonspecific, it is likely that an unknown amount of the data consisted of false positives. The lack of quality assurance information coupled with the large fluctuations observed in some of the data and the questioning of some of the conclusions leads to the premise that the data, and hence the conclusions reached, may be of limited use.

C. Paper No. C-71: "Continuous, Automatic Detection of Organophosphates and Carbamates in Water Utilizing Enzyme Microcalorimetry" by W. S. G. Morgan, P. C. Kuhn and P. P. van Niekerk (South Africa)

This paper summarized the development of a new method to detect low levels of organophosphorus and carbamate insecticides in water. The method is based on calorimetry and uses an immobilized cholinesterase to measure these compounds. The immobilized cholinesterase activity is measured in a microcalorimeter by analyzing its catalytic efficiency in hydrolyzing a substrate solution passed over the enzyme at regular intervals. Automation and data acquisition was facilitated by use of a microcomputer.

The obvious concern is one of specificity and false positives by using such a nonspecific method of detection. The author pointed out that specific enzymes may be found to detect heavy metals, phenolic compounds, cyanide and carcinogenic aromatic amines. The results presented in this paper are to be considered preliminary ones which demonstrate the feasibility of developing similar monitoring systems. A search for enzymes which will be inhibited by specific toxicants is the next logical step in future developments of this methodology. The ultimate objective is to have a multienzyme hazard detection system where specific toxicants can be detected using specific enzyme systesm. The name given to this new methodology is "AESOP"--Automatic Enzyme Surveillance of Pollution.

Baker (U.S.A.) raised the questions of interferences when using a multienzyme system, long-term (memory) effects on the substrate system and use of reference columns. The author was of the opinion that the computer will be able to differentiate which enzyme(s) are being affected and be able to calculate a slope which is indicative of the level of hazard caused by the pollutants. However, the actual concentration levels can not be calculated using AESOP. A 5- to 30-minute exposure to the pollutants was usually needed to provide data for a good slope. It was also shown that toxicants adhere to the immobilized enzymes. This may be used to advantage. If the toxicants can be desorbed and collected, they can then likely be identified and perhaps quantitated by traditional analytical methods. Because of the preliminary nature of this work, each enzyme had been used as its own control, but the author agreed that in a "formal system" a parallel stream would have to be passed through a "control" or "reference" column for each enzyme.

Another important aspect of this new methodology is the expected lifetime of the immobilized enzymes. To date, experiments to determine this parameter have only been done with acetylcholinesterase, yet the results are encouraging. Over an eight-week usage period with four different columns, only a 7% to 10% loss in enzyme activity was observed.

If AESOP can be refined sufficiently to provide reproducible and reliable data, it may produce a new type of monitoring system that offers advantages over other methods in certain defined situations. It is clear from the work presented that, although the system has possibilities, it is too early to make any definitive statements in this regard. It is a novel idea that bears careful attention during the critical phases of its development over the next several years.

D. Paper No. C-72: "Biological Assessment of Water Quality in Running Water Using Macroinvertebrates: A Case Study for Limburg, The Netherlands" by H. H. Tolkamp (The Netherlands)

This paper presented an evaluation of water quality of streams through a comparison of the macroinvertebrate composition of them. Seven methods were evaluated and four were found which gave promising results: the Saprobic-index, the Quality-index, the BMWP-aspt and the Chandler-aspt. Frequency distributions of various classes, statistical correlations among the methods and much data were included in this paper. All of the indices discussed were calculated by using the same species list for each station. This resulted in highly variable results among some of the indices for the same sampling stations. Thus, these biological assessment methods must be applied with care and should always be accompanied by a definition of the achievable maximum, or the total index range, which is applicable to the stream type under study. Of course, the reference community for the stream type under study must be well known or be determined to be able to specify the total index range. The authors considered the various biotic indices unfit for use in their present form and plan further refinements in the future.

There seem to be many uncertainties and variables in the use of this type of methodology to try to characterize water quality in a reproducible and reliable manner. Optimal biological assessments can be achieved only through regional adaptations of methods which reflect both biogeographic and biotypological differences between various streams. Some of the indices are quite variable with respect to seasonal sampling while others show less dependence on this factor, but it was noted that the authors concentrated primarily on spring and autumn sampling times. A South African participant volunteered that they found that one could simply concentrate on the dry season for sampling in South Africa. If limited to one sampling season due to financial or other constraints, autumn is generally considered the single best season to sample because the animals will be full grown and easier to identify and classify.

Discussions also revolved around correlations of water quality from these biologically-founded indices with those based on chemical parameters. The point was made that the variations obtained are so large that the relationships usually cannot be made. Statistical correlations can be made occasionally, but not relationships between these biological and chemical indices. It was speculated that the sampling techniques may be a major source of these large variations, but whatever the reason, it is an indication that the biological indices are not nearly as developed, reproducible and reliable as many of the chemical methods of determining water quality. Considering the labor intensiveness and cost of measuring water quality parameters with macroinvertebrates versus chemical measurements, it appears that the former has little to offer in terms of advantages.

E. Paper No. C-73: "Aquatic Habitat Analysis as an Element of Water Resources Planning and Management" by E. E. Herricks (U.S.A.)

The premise of this paper was that consideration only of water quality for water resources and management is insufficient; the quality of the aquatic habitat is also very important. Managing water resources to provide high quality aquatic habitats involves planning to meet water quantity as well as water quality objectives. Based on this premise, an example of aquatic habitat management in Illinois was presented using Incremental Methodology developed by the U.S. Fish and Wildlife Service. This Incremental Methodology is a computer-based analysis system named PHABSIM (PHysical HABitat SIMulation). PHABSIM consists of a hydraulic simulation routine which requires the collection of field data, depth and velocity information and a hydraulic simulation model which provides depth and velocity data at various flows for the representative sampling area. A critical feature of habitat analysis using this methodology is selection of representative reaches of the stream being sampled and validation of the extrapolation of representative reach analysis results to the entire basin.

The primary output of PHABSIM is species and life-stage-specific habitat data. Habitat response curves can also be generated using this system, and these have different characteristics not only for each species but also for each life stage within the various species. This system of habitat analysis, and habitat frequency analysis in particular, was used to assist in the development of a flow regulation policy in the state of Illinois. Interim flow standards were developed and evaluated using PHABSIM, and it was found that the impact of the proposed interim standard was different for different rivers.

Using habitat analysis, it was possible to generalize the impacts which might be caused by the adoption of a standard. One of the important findings from this study was that habitat can be increased in certain situations by reducing flows.

It was assumed that this modeling system could also be used with marine systems with appropriate modifications. Another extension which may prove to be useful is the use of the habitat response curves and frequency analysis curves to generate nomographs of the data. The audience in general was perceived to have a positive response to the potential advantages and applications of using habitat analysis to improve water resources quality and management.

4. CRITIQUE OF SESSION

These papers varied significantly in terms of quality, theoretical basis, approach and potential application to solving real-world problems. Paper No. C-69 was highly theoretical, but did provide a model that may be able to calculate the concentrations of the major ions of interest from two easily measurable parameters (conductivity and pH). However, it is such a complex model that most individuals will tend to use the simpler traditional regression equations unless the model is simplified. In contrast, Paper No. C-70 was highly applied, but the documentation of the methods used was so poor and the data so variable and likely to contain false positives, that it is useless as presented. Paper No. C-71 presented a new concept in monitoring pollutants, but in its present form it is still not useable. Considerable research will be required to develop enzyme microcalorimetry to the point where it is useful and reliable, but even then this technique may be limited because it is too nonspecific and cannot provide concentrations of pollutants. Paper No. C-72 tried to present an argument for using macroinvertebrates as a method of providing biological assessments of water quality, but the method is so labor intensive and the data of such variable quality, that it didn't appear to be a very promising technique when other cheaper, more reliable chemical methods are available. The last paper of this session

(No. C-73) provided a modeling system that appeared to be useful in evaluating flow controls in aqueous habitats.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The significance of the papers presented in this session is limited. Most of them discussed methodologies which appeared to be limited in scope and utility even if they are refined to the point where they will provide reliable and reproducible data. The two exceptions were the papers involving computer-based modeling systems. Habitat analysis has been shown to be a useful addition to traditional water quality analysis and should be seriously considered where impacts of flow control to an aquatic habitat are being evaluated.

1. SESSION

A. Day: Tuesday, September 18, 1984
Location: Hall 3
Time: 9:00 a.m. to 12:25 p.m.

B. Themes of Session: Resuspension and Sedimentation and Benthal Deposits

2. REVIEWER

A. Name: Curtis W. Bryant, Jr.

B. Position and Affiliation: Assistant Professor, Department of Civil Engineering, University of Arizona, Tucson, Arizona (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

A. Paper No. C-74: "Erosional Process of Cohesive Sediments" by T. Kusuda, T. Umita, K. Koga, T. Futawatari, and Y. Awaya (Japan)

Laboratory tests were conducted to measure the rate of erosion of cohesive sediment samples. Results showed a marked decrease in the erosion rate after only 20-30 minutes. A time-dependent Bingham model of the measured phenomenon was developed.

Kusada (Japan) characterized the study as an initial, fundamental effort and indicated that further work would be required for application of the model to actual field conditions. In response to questions from Somlyody (Hungary) and Baker (U.S.A.), Kusada (Japan) stated that comparison of individual sediment studies was not appropriate due to the differences in sediment properties. Also, model application to actual problems was currently infeasible because of three effects that cannot be simulated: vertical nonhomogeneity of sediments, variability of storm events, and the steady-state erosion by waves and large-scale turbulence.

B. Paper No. C-75: "Quantification of Wind Induced Resuspension in a Shallow Lake" by R. H. Aalderink, L. Lijklema, J. Breukelman, W. van Raaphorst, and A. G. Brinkman (The Netherlands)

The suspended solids concentration in a shallow lake was modeled as the net result of settling and resuspension, and four expressions for the resuspension term were evaluated. The best description of field data was produced by an empirical expression based on flow-field-induced shear stress. Separate field measurements of the effective settling velocity compared favorably with the parameter estimate generated by the model.

The modeling approach described by Lijklema (The Netherlands) included several notable aspects: field data collection for model calibration, separate field measurements for partial model validation, a balance beween theoretical and empirical inputs to model development, and a specific water management objective for the modeling project. Comments by the official discusser, Somlyody (Hungary), noted the different objectives of the two papers presented thus far. The first paper was characteristic of research oriented towards a hydraulic engineering goal, which dictates the precise evaluation of direct effects observed in a local field of study. The second paper reflected research oriented towards a water quality management goal. The orientation towards practical application dictated an approximation of indirect effects averages over an entire lake or basin. No preference was specified for a particular method, but attention was drawn to the importance of goal definition as a determinant in the seleciton of an appropriate research approach.

C. Paper No. C-76: "The Behavior of Suspended Sediments and Muds in an Estuary" by T. Umita, T. Kusuda, Y. Awaya, M. Onuma, and T. Futawatari (Japan)

The effects of a cyclical shear stress condition upon suspended sediments were studied in a laboratory apparatus. Results indicated that effects were limited to small particle sizes and a model was developed to describe the three pertinent phenomena: erosion, dispersed-particle deposition, and flocculent-particle deposition.

Umita (Japan) was asked by Lijklema (The Netherlands) to define the nature of the particles which were exerting the flocculation effect. The most pertinent value given in the response was the 12% ignition by weight for the entire deposit, indicating the organic content. Umita (Japan) was also asked by Kelderman (The Netherlands) to comment on the application of the results to a wide range of estuaries. Umita (Japan) indicated that only laboratory conditions had been addressed to date and that application to real estuaries was premature. Collection of field data from a real estuary was underway, and simulation of that system would be attempted in the near future.

D. Paper No. C-77: "Stabilization of Organic Carbon and Nitrogen in Consolidating Benthal Deposits" by C. W. Bryant, Jr. and L. G. Rich (U.S.A.)

The research focused on high-organic deposits covered by an aerobic water column and formed by continual deposition. A theoretical model of consolidation and microbial reactions for the benthal condition was developed. Model predictions were compared to time-dependent interstitial profiles measured in laboratory deposits developed over fifteen weeks. Significant results presented by Bryant (U.S.A.) included the prediction that benthal stabilization capacity far exceeded the loading rates currently used for lagoon design.

The official discusser, Lijklema (The Netherlands), noted with approval the combination of modeling and independent laboratory validation used. Lijklema (The Netherlands) suggested the inclusion of the hydrogen partial pressure in inhibition modeling to alleviate simulation problems in that portion of the model. Finally, Lijklema (The Netherlands) stressed the need for study of various loading rates to enhance validation of the proposed model.

E. Paper No. C-78: "The Calculation of Transport Coefficients of Phosphate and Calcium Fluxes Across the Sediment-Water Interface, from Experiments with Undisturbed Sediment Cores" by W. van Raaphorst and A. G. Brinkman (The Netherlands)

Continuous and batch experiments were used to investigate the fluxes of phosphate and calcium across the sediment-water interface. It was concluded that the flux rates were a direct function of desorption within the top millimeter of the sediment rather than diffusion from deeper layers. It was also emphasized that the simplicity of the proposed model enhanced its utility as a water quality management tool.

4. CRITIQUE OF SESSION

The session was of significant value as a concise example of the contrasting, valid approaches available for application to the development of environmental models. As summarized by Somlyody (Hungary), the models in Paper Nos. C-74 and C-76 were precise hydraulic engineering products that were not yet ready for use in real systems. The models in Paper Nos. C-75 and C-78 were tools useful for approximations required in water quality management decisions. Paper No. C-77 represented an intermediate approach between the laboratory and field approaches of the other models.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The observed range of product models emphasized the importance of initial goal definition and subsequent coordination between the researcher and the potential users to insure that the development effort focuses on the appropriate data base and degree of complexity. This point is fundamental for the production of useable water quality management tools.

1. SESSION

   A. Day: Tuesday, September 18, 1984
   Location: Hall 3
   Time: 2:00-3:45 p.m.

   B. Theme of Session: Modeling Water Quality

2. REVIEWER

   A. Name: David W. Hendricks

   B. Position and Affiliation: Professor of Civil Engineering, Colorado State University, Fort Collins, Colorado (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-79: "Stream Modeling of Nonconventional Water Quality Parameters: Phenol, Cyanide, Ammonia, Oil and Grease" by A. B. M. Shahalam (Jordan) and D. A. Burke (U.S.A.)

Because neither Shahalam (Jordan) or Burke (U.S.A.) were present to present the paper, there was no discussion. The paper did, however, provide the basis for what could have been a valuable dialogue, since it addressed many of the fundamental issues of water quality modeling. At the same time, some of the critical documentation was lacking.

The paper briefly outlined the components of a water quality system and the interactions between its different categories of components, such as external loadings, external environmental factors, aquatic chemical factors, and aquatic biological factors. Further, the paper described the basis for the model constructed which combined the materials balance equation for a stream element and kinetics. The paper also showed the water quality character of the lower 23 miles of the Monongahela River (U.S.A.) by means of time and distance graphical depictions of temperature, pH, total biomass, cyanide, and phenol. This reach of river had a total of 199 discharges. Each of these was characterized in terms of frequency plots.

Empirical kinetic equations were described which incorporated, as needed, biodegradation, volatilization, hydrolysis, photolysis, sorption on solids nd microbial flocs, and chemical oxidation. The model verifications depicted both order-of-magnitude levels and trends with river kilometer for phenol, total cyanide, ammonia, and oil and grease.

The modeling verification effort must have required extensive field measurements for the assembly of a large amount of data such as waste discharges, river flows, river cross sections, dispersion coefficients, sediment concentrations, and a host of other data related to the kinetic models. There was no mention of this. Because of the lack of documentation, the work is of limited usefulness. The reader is both deprived of appreciation of what must have been an extensive study, and the confidence in the development of coefficients and various input data which goes with documentation. Further, the conclusions do not relate to the main issues raised in the paper on the topic of water quality modeling and how to do it. Rather, the authors described some of the virtues of water quality modeling. These authors, if present, could have reacted to these points and thus focused on some of the most pertinent issues of water quality modeling. The paper had the potential to stimulate such discussion.

B. Paper No. C-80: "Modelling of Oxygen Depletion in Coastal Waters" by A. Malmgren-Hansen, P. Mortensen, and B. Moller (Denmark)

The paper, presented by Mortensen (Denmark), modeled dissolved oxygen in the portion of the Limifiord in the northern part of Jutland, Denmark, called Thisted Broad. The fjord is a shallow basin having two tidal inlets to the North Sea.

Dissolved oxygen levels in the Limfiord Fjord in Denmark have been measured in recent years at zero in certain zones and appreciably less than saturation levels over others. Most of the fjord has experienced this condition during the years in which measurements have been taken. Also in recent years, shellfish harvesting has declined, which may be approximately coincident with the periods of low oxygen. It was not certain, however, whether these low oxygen levels were naturally occurring or were man-induced. Since some waste loads are discharged into the fjord, a question was pertinent to a pending program of pollution abatement. The question was: What is the relationship between the present and possible future waste discharges and the spatial distribution of oxygen in the fjord?

To address this question, the authors constructed a rather comprehensive water quality model of selected vertical profiles within the estuary. The model incorporated oxygen transfer at the surface as affected by wind speed and temperature, primary production in the vertical profile and oxygen production and respiration, benthic oxygen demand, phosphate and nitrogen concentrations and their effect on primary production. The model was called a "box" model, as a category, which examined these phenomena within a set of finite boxes comprising a portion of the vertical cross section, while accounting for mass transfer between boxes by diffusion and convection due to wind-induced eddies.

The model predictions of oxygen profiles corresponded well to measured conditions. Using the model, the appraisal was made that the existing waste discharges do not contribute significantly to the episodes of low oxygen levels.

The formal discussion focused mostly on the concept of the box model. The discusser seemed to understand the premises of the model, even though these were not stated explicitly either in the written paper or the verbal delivery. The box model was essentially another adaptation of the materials balance principle applied to elements within a vertical column.

The research was sophisticated theoretically and apparently well documented with field data, though here also the reference report for these data was not cited. It was surprising that the simulations were so well validated in view of the number of variables incorporated in the model.

C. Paper No. C-81: "Water Quality Modeling of the Lower Han River, Korea" by L. F. Tischler (U.S.A.), R. M. Bradley (U.S.A.), S. J. Park (Korea), and D. G. Rhee (Korea)

Tischler (U.S.A.) presented the paper which outlined how QUAL II was applied to examine the effects of alternative wastewater management plans on dissolved oxygen objectives for the Lower Han River in Korea. The paper described the process of calibration and verification of the model, the role of sensitivity analysis, and the simulations obtained for alternative treatment plant configurations. The model was used to simulate dissolved oxygen, BOD, ammonia, fecal coliforms, and several others. The modeling process illustrated how two regional wastewater treatment plants were recommended as the most cost-effective alternative means of attaining the dissolved oxygen water quality objective. Other water quality objectives would be attained as a consequence of meeting the dissolved oxygen objective. The paper did not develop new knowledge, nor did it intend to do so. Rather it illustrated, with an example, and for conditions somewhat different than in the U.S.A., how the water quality modeling process is accomplished and how it is utilized as an engineering tool.

Barnwell (U.S.A.), the official discusser, raised several questions having to do with the technical aspects of the modeling process. He suggested that the time of travel should have been based upon a dye study instead of a calculation, that one data set should have been withheld for additional verification, and that the parameter values used should have been in the report.

Park (United Kingdom) was originally from Korea and knew the Han River and suggested that the width of the river was also a major factor in its mixing. Further, the dispersion coefficients could have had additional factors incorporated. Tischler (U.S.A.) felt that because the model objectives were limited, further resolution was not appropriate for the study and that improvements could be incorporated in the model as they became available.

4. CRITIQUE OF SESSION

Paper Nos. C-79 and C-81 were on water quality modeling of streams, while Paper No. C-80 modeled the oxygen balance of a shallow fjord. None of the three papers was intended to create new knowledge. All three were useful illustrations, however, of the various problems, dilemmas, and limitations of adapting a theoretical concept, the water quality model, to be useful as an engineering tool. While the critics have mentioned the scientific limitations of determining coefficients, and velocity data, the modelers in facing an engineering problem have had to make the necessary approximations to meet time and budget limitations. These included such questions as deciding where to measure data for validation, when and how long, and the number of validation runs needed. Uncertainty of coefficients and their effect on model simulations is another major area of interest in actual applications. Such questions are at the core of the art aspects of water quality modeling, and although the demonstrations help one to understand the critical areas of modeling, they do not provide definitive guidance--nor should this be expected. The three models demonstrated also are good examples of the diversity of field applications of the material balance principle, both with respect to the kinds of situations addressed and the different ways in which the models were constructed.

Thus it is important to realize that, although the rationale for water quality modeling is scientific, its application is engineering art. It is important not to confuse these two areas. Because of this, case study examples such as the papers given, and their critiques, help to define a state-of-the-art of water quality modeling. Also, as pointed out during the floor discussion, it is extremely difficult to provide a comprehensive review of a modeling effort. Because of this, the papers should have referenced source reports where the reader can find needed documentation and elaboration on how the problems were resolved. While this was a major deficiency for all three papers, they were, individually and collectively, useful contributions to the field from the standpoints noted above.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

No new scientific knowledge was generated by these papers nor have new concepts or approaches been developed. The further demonstration of the water quality modeling process illustrated, however, both the utility and the limitations of such models. In addition, the modeling demonstrations showed the variety of situations which can be modeled and the various ways in which models can be constructed and used as engineering tools. The field is new enough (e.g., 15 or 20 years) that the questions addressed implicitly in the three papers are not common knowledge except to those who have specialized in the field. Further, activity in this area has declined appreciably over the past six or seven years. Thus, adding to the literature of the field contributes to and keeps attention on the field, which is necessary for continuing vitality of this aspect of the U.S.A. water pollution research effort.

These models were adopted formally in the U.S.A. water pollution research program beginning in the early 1970's, the limitations of the state-of-the-art notwithstanding. Modeling is still needed to advance the state-of-the-art beyond the initial efforts of these early years.

1. SESSION

A. Day: Tuesday, September 18, 1984
Location: Hall 3
Time: 4:15-5:30 p.m.

B. Theme of Session: Dispersion in Estuaries

2. REVIEWER

A. Name: David W. Hendricks

B. Position and
Affiliation: Professor of Civil Engineering, Colorado State University, Fort Collins, Colorado (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

A. Paper No. C-82: "A Role for a Simple Discrete-Time Model to Describe Dispersion in an Estuary" by T. Wood (Australia)

Wood (Australia) delivered a provocative paper in which his theme was that of using simple models for estuary exchanges. By contrast, the more complex finite-element materials balance models require a great deal of data, and there is much uncertainty in determining the coefficients. His model was illustrated for the estuary of the Hawksbury River near Sydney, Australia, in which the 140-km estuarine reach was divided into only five segments, each of which was assumed to be homogeneous in operating the model. Only salinity was modeled. The input data required was the sequential average salinities of each segment at high and low tides, freshwater inflows, tidal levels with time and estuary geometry. The modeling equations were based upon the concept of the extended Kalman filter. Intuitively, they were not explained fully, but they seemed to incorporate the idea of a driving force term, e.g., elevation difference between high tide and low tide, and salinity difference between high tide and low tide, to predict a new state variable. The predicted average salinity concentrations for the middle segments was shown to agree within a few percent of the measured salinity concentrations.

The official discusser, Kashuda (Japan), felt that the paper was one of the most interesting of the conference since the important issues of time, cost, and effort of data procurement were central to the rationale for the model proposed. Two questions raised by Kashuda (Japan) related to how segment size was determined and what noise factors were taken into account. The author replied that the segment size was arbitrary, and judgment was used based upon knowledge of the system. To the second question, he replied that estimations of fresh water flows were most critical.

The author expressed surprise that the continuum modelers did not take issue with the premises of his simplified approach. This stimulated extended responses from Martinez (Portugal), Kald (Sweden), Park (Korea), and Mortensen (Denmark), all of who gave amplification to the basic themes of the paper. Martinez (Portugal) liked the idea of the simple model because of the effort needed to collect data for a large system and inquired about adding temperature and non-conservative parameters. The author responded that degradation terms could be incorporated, but that if the hydraulic terms have much uncertainty associated with them, the kinetic equations have even more, and that practice is still at a beginning stage in the modeling art. Kald (Sweden) expressed surprise that only five segments were used and that it would be easy from a computational standpoint to add more segments and to produce more refinement. Wood (Australia) replied that he wanted to ascertain how few could be used, and it was not feasible to have field monitoring for more segments. Park (Korea) felt that the proposed model is valid only for certain situations, e.g., where sudden changes in hydraulic conditions are not likely. The author replied that any model is limited by the knowledge available on boundary conditions. Mortensen (Denmark) felt that a more sophisticated hydraulic basis was needed for the model, particularly a means to incorporate disperson coefficients would be desirable. The author pointed out that the model has built in both advective and dispersion transport, but the latter does not have a dispersion coefficient. He closed by adhering to his theme that the model should be made for the objectives in mind and that an engineering model should do this.

B. Paper No. C-83: "Tidal Variation of Salt Flux and Dispersion in a Polluted Estuary" by J. K. Park and A. James (United Kingdom)

James (United Kingdom) indicated the objective of the work was to ascertain dispersion mechanisms for estuaries to be incorporated later in a rather comprehensive water quality model. The purpose of the model will be to determine pollution loads consistent with water quality goals. The Tyne River estuary, which is about 30 km in length, was the basis for the field study. The mixing patterns in the estuary were complex and are caused by tidal movements and the salinity gradient, which required a detailed hydrodynamic model. The dispersion coefficient, a main concern of the model, was a function of depth, mean velocity, and dimensionless parameters. The coefficient was found to be time varying and could be expressed as a sine function. The method of analysis of the field data permitted determination of the components of the dispersion process.

Mathew (Ireland) suggested that there is little difference in the results between using a constant or a time-varying dispersion coefficient, and questioned whether using the time-varying coefficient was warranted, especially since the effort is great to define the empirical function. The authors replied that their quest was to ascertain mechanisms of dispersion and that to do this, a time-varying function is necessary.

4. CRITIQUE OF SESSION

The two papers of this session were at opposite ends of the spectrum of modeling approaches, and for that reason they complemented one another. The paper by Wood (Australia) was based upon classic engineering empiricism. The mathematical depiction was the minimum needed to achieve the purpose at hand and the field data for validation was minimal. It was geared to achieve the proverbial "quick and dirty" solution, insofar as this is possible with estuarine-type problems. Although the theoretical basis was thin, one cannot argue with results that are in substantial agreement with field data. While one should not embrace this model wholeheartedly and without reservation, it should be considered by researchers who might wish to extend it to non-conservative water quality parameters.

The paper by Park and James (United Kingdom) was highly theoretical and would require an extensive amount of data to validate. It is mathematically sophisticated, and its use would be restricted to the hydrodynamic specialist who is familiar with estuaries. The model can simulate cross section profiles of water quality constituents and the changes with time. Such information may be useful for some situations.

Both papers need reference reports to permit those interested to learn more and to document the findings in the paper. The papers are valuable as side-by-side contributions to illustrate modeling approaches which are at opposite ends of the spectrum.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The idea of a simplified estuarine model of Wood (Australia) would be useful as an approach for some situations. Perhaps it could be an evaluative tool to determine whether further studies could be useful. In some situations only limited information is needed, and this kind of model would be useful.

The work of Park and James (United Kingdom) seemed to be scientific in nature, with little likelihood of immediate application as an engineering tool. It constitutes the kind of long-term commitment to basic knowledge needed to sustain a water pollution research program.

The idea of estuarine modeling is not new, and there are no innovative ideas that might have a singular effect on the U.S.A. water pollution research program. Rather, the papers are valuable in that they represent a continuing research activity in the field in which in itself is useful, especially since research activity in the U.S.A. has been scant over recent years.

1. **SESSION**

   A. Day: Wednesday, September 19, 1984
      Location: Hall 3
      Time: 9:00 a.m. to 12:30 p.m.

   B. Theme of Session: Physical/Chemical Treatment

2. **REVIEWER**

   A. Name: Walter J. Weber, Jr.

   B. Position and Affiliation: Professor of Civil and Environmental Engineering, The University of Michigan, Ann Arbor, Michigan (U.S.A.)

3. **DESCRIPTION OF SESSION PAPERS**

   A. Paper No. C-84: "Factors Affecting the Adsorption of Complexed Heavy Metals on Hydrous Al_2O_3" by H. A. Elliott and C. P. Huang (U.S.A.)

This paper, part of a more extensive and comprehensive study by Huang (U.S.A.) and co-workers of metal ion uptake by a variety of adsorbents, described studies of the effects of an organic complexing agent, nitrilotriacetic (NTA), on the adsorption of several heavy metals on λ-Al_2O_3. The metals included Zn(II), Cd(II), Pb(II) and Ni(II), but the study focused primarily on Cu(II), copper being found in preliminary studies to adsorb more extensively on the λ-Al_2O_3 than did the other metals. Variables studied included NTA concentration, pH, ionic strength, temperature, and background Ca(II) and Mg(II) concentrations.

The invited discussion by Joko (Japan) centered on reasons for the choice of the adsorbent (well characterized and similar to the activated aluminas used in water treatment according to the presenting author). The floor discussion raised questions about the possible dissolution of the λ-Al_2O_3 in certain pH ranges and by complexation of Al(III) by NTA at the higher (as high as 10:1) molar ratios of NTA:metal (both negligible according to Huang (U.S.A.)).

The authors presented interesting data which, if subjected to somewhat more intensive analysis than given in this particular paper (particularly in the broader context of the overall studies by Huang (U.S.A.) of the adsorption of metal species on different adsorbents) would yield some useful insights to the mechanisms of association of metal species with solid surfaces. The immediate practical significance of the work may be limited, however, by the fact that several more efficient and/or cost effective means exist for heavy metal removal from waste waters (e.g., precipitation and ion exchange).

B. Paper No. C-85: "Infrared Thermal Regeneration of Spent Activated Carbon from Water Reclamation" by B. M. van Vliet and L. Venter (South Africa)

Van Vliet (South Africa) presented the details and conclusions of a parametric study of the effects of temperature and residence time on the reactivation of spent carbon in an infrared conveyor-belt furnace. The evaluation of regeneration effectiveness is predicated principally on restoration of an intraparticle structure and pore size distribution approximating that of the virgin carbon, minimizing carbon losses, and maintaining adsorption characteristics. Pore size distribution is a recognized indicator of the adsorption behavior of a carbon. One frequent problem in thermal regeneration is the conversion of micro- and meso-pore volume to macro-pore volume, accompanied by carbon losses due to burn out and increased friability and changes in adsorption properties.

Both the invited discussion by Schultz (U.S.A.) and some floor discussion was active and focused on two primary issues, the extensibility of the findings to carbons other than that studied, and the question of cost comparisons to alternative thermal regeneration techniques. The author indicated that similar work has since been done on carbon prepared from a different raw material and used in a different application (coconut carbon used in gold recovery operations) with qualitatively similar results. Although he has not yet performed detailed cost analyses, the author felt that the lower carbon losses associated with the IR technique should make it cost competitive with regeneration in multiple hearth furnaces or rotary kilns. More accurate operation and closer product control were cited as major advantages of IR furnace regeneration.

C. Paper No. C-86: "Organic Removal Mechanisms in Biophysical Treatment Systems" by J. R. Schultz and T. M. Keinath (U.S.A.)

The thrust of the work described by Schultz (U.S.A.) was an attempt to identify and quantify the respective roles of enhanced bioactivity, carbon regeneration, and metabolic end-product (MEP) adsorption and degradation in activated sludge systems to which powdered activated carbon (PAC) is added. The work was carried out with phenol because this substrate is known both to adsorb on carbon and to be degraded biologically. A radio-labeled phenol was used to facilitate end-product tracking and low-level detection. The essential conclusions of the study were that there was no evidence of biodegradation enhancement, that adsorbed phenol was removed by bioregeneration, that the MEP's were resistant to further degradation, and that somewhat more than half of the MEPs were adsorbed irreversibly.

The discussion was lively with many comments from the floor. Among other things, the invited discussion by DiGiano (U.S.A.) challenged the conclusion that PAC did not enhance the rate of biodegradation of phenol, citing some of the authors' data. The authors explained that the apparently contradictory data were suspect and thus not used in arriving at their conclusions. Several floor discussors felt there should be enhancement of biodegradation by PAC. Another point of the discussion was that the finding that the MEP's were resistant to degradation was not at all surprising because the ones collected were those which had already persisted for a long time in the same medium in which their biodegradability was subsequently measured.

D. Paper No. C-87: "Ozone Enhanced Biological Activated Carbon Filtration and its Effect on Organic Matter Removal, and in Particular on AOC Reduction" by J. G. Janssens, J. Meheus and J. Dirickx (Belgium)

Janssens (Belgium) described the results of a pilot plant study on the effectiveness of preozonation on the operation of granular activated carbon (GAC) filters in water treatment applications. The findings were that ozone dosages up to 2 mg/L increased filter service time by 60-65% in terms of total organic carbon

(TOC) removal, probably due to increased biological activity, but that the ozone also resulted in significant increases in (and earlier breakthroughs of) assimilable organic carbon (AOC) levels in the adsorber effluents. Dosage levels higher than 2 mg/L did not further enhance TOC reduction. The authors concluded that the detrimental aspect of increased AOC levels and earlier AOC breakthrough outweighed the benefit of increased filter service time for TOC removal.

The invited discussion by Vennekens (South Africa) compared the results to studies conducted by the NIWR in South Africa using a reclaimed wastewater as influent and confirmed the finding with respect to AOC. This discusser also raised questions about the accuracy of AOC determinations, indicated that the NIWR had found an O_3 dosage level of 4 mg/L was most cost effective and gave a 300% increase in carbon service life, and suggested that O_3 addition may also function to strip volatile compounds. The latter point is noteworthy because volatile compounds are often the first to break through GAC beds.

Several comments were offered from the floor. One suggested the possible use of bioactive sand filters after ozonation and before GAC treatment to reduce AOC breakthrough. Another cited beneficial effects of preozonation beyond those mentioned by the authors, namely the findings by Dutch researchers in KIWA of reduced mutagenicity and THM formation potential.

E. Paper No. C-88: "Ozonation of Non-Ionic Surfactants in Aqueous Solutions" by N. Narkis, B. Ben-David and M. S. Rotel (Israel)

Narkis (Israel) presented this report on a laboratory study of the oxidation of non-ionic nonyl phenol ethoxylate surfactants by ozone. The study focused on a characterization of the effects of chain length on the kinetics of surfactant breakdown and reduction of UV-absorbance, COD and TOC. A first-order rate expression was used to describe the time-dependence of the oxidation process. A major result of the work is that the partial cleavage of complex surfactant molecules was found to significantly enhance the biodegradability of residual fractions.

The invited and floor discussion generally supported the finding of increased biodegradability of complex organic compounds after ozonation. The invited discussion by Saunders (U.S.A.) raised an important question regarding the use of a first-order rate expression to describe a process which is likely mass-transfer limited. While first-order expressions may reasonably describe data traces in such instances, care must be taken in the interpretation of resulting rate coefficients, and particularly in extrapolating the results beyond the particular experimental conditions employed to obtain the data.

4. CRITIQUE OF SESSION

The five papers of this session covered a rather broad range of subject matter as well as a wide range of research approaches. As a result, there was no true continuity in subject matter, in the make up of the audience, or in the floor discussion.

Paper Nos. C-84 and C-88 were perhaps furthest separated in terms of subject matter, but most similar in terms of both the detail and character of the data and information, as well as immediate applicability of that information. The data contained in these papers are substantial and of good quality, but of limited immediate applicability to practice.

In terms of significance for the U.S.A. wastewater treatment industry, Paper No. C-85 on IR regeneration, and Paper No. C-86 on biophysical systems, were most valuable. Both focused on highly pertinent issues having direct practical bearing on the field and both represented substantial work of good quality. The areas of research dealt with by each of these two papers are clearly significant and deserving of further pursuit.

Paper No. C-87 on preozonation of GAC dealt with an important subject, particularly for the water supply industry, but, as a pilot study was more site specific and less general in character than the other papers of the session. Nonetheless, the interest from the floor and the somewhat different perspectives presented by the participants confirms the importance of the area for further research, particularly of a more basic and general character.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

Two of the papers presented at this session are of particular and immediate significance and value for U.S.A. water pollution research, namely Paper Nos. C-85 (IR regeneration) and C-86 (biophysical systems).

Paper No. C-87 (preozonation of GAC), while not directly contributing as much generally applicable data and information as Paper Nos. C-85 and C-86, is significant in that it underscores a need for more fundamental research in the area of preoxidation and bioactivity in GAC systems. The remaining two papers, Paper Nos. C-84 (metal adsorption) and C-88 (surfactant oxidation), dealt with subjects of somewhat less significance for U.S.A. research efforts in water pollution, although No. C-88 suggested potentially useful area of research, namely preoxidative treatment of recalcitrant wastes prior to conventional biological treatment.

1. SESSION

   A. Day: Wednesday, September 19, 1984
      Location: Hall 3
      Time: 2:00-5:25 p.m.

   B. Theme of Session: Physical-Chemical Treatment

2. REVIEWER

   A. Name: John R. Schultz

   B. Position and
      Affiliation: Assistant Professor of Civil
      Engineering, University of Utah,
      Salt Lake City, Utah (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-89: "Influence of Bubble Sizes on Ozone Solubility, Utilization and Disinfection" by M. Ahmad and S. Farooq (Saudi Arabia)

This paper presented the results of a laboratory study examining the effects of ozone bubble size on ozone residuals and the disinfection of a secondary wastewater effluent. Bubble sizes were varied by changing diffuser porosity and ozone gas flow rates. The results showed that smaller bubble sizes gave both higher ozone residuals and disinfection efficiencies for a given gas flow rate. The ozone utilization, however, was found to decrease as the bubble size was decreased by increasing the gas flow rate. The author indicated these results suggest that an optimal bubble size and degree of mixing may exist in terms of process economics. The optimal conditions were not found in the study.

The discussion centered on two issues: The first was the effect of surface-active agents in the secondary effluent on the mass transfer process. Sirka (U.S.A.) stated that surface-active agents tend to yield ellipsoidal bubbles and questioned how the bubble diameters were determined. The author replied that the bubbles were indeed ellipsoidal and that the given diameters represented the average of the minor and major axes. The question of the effect of surface-active agents on the rate of mass transfer was also raised.

The second issue raised was the effect of free oxide radicals formed from the decomposition of the ozone. These radicals may be more efficient disinfectants than ozone and were not discussed in the paper. Moreover, the formation of these radicals is pH dependent. The author replied that the pH of the wastewater was between 7.5 to 8.0 and emphasized that ozone processes need to be analyzed using the two-film theory presently used for aeration processes.

B. Paper No. C-90: "The Role of Rapid Mixing Time on a Flocculation Process" by R. J. Francois and A. A. Van Haute (Belgium)

This paper presented the results of a laboratory study examining the effects of rapid mixing time on the flocculation of a kaolinite suspension using an aluminum salt as the coagulant. Turbidity and particle size measurements were used to measure flocculation effectiveness and a four-level floc-structure model was used to interpret the results. The author concluded that the optimal rapid mixing time was between 30 and 60 seconds.

O'Melia (U.S.A.) pointed out that more knowledge about the chemistry of the coagulant species is necessary before a practical approach for designing coagulation and flocculation processes based on theoretical concepts can be developed. He questioned the transferability of both the procedures and the results to other colloidal suspensions because his own experimental results did not agree with those obtained by the author. The author responded that his collison efficiency factors were much lower than previous results, but no explanation was offered.

Another discusser pointed out that the objectives of rapid mixing may be different for contact filtration processes where it may not be desirable to have much aggregation in the rapid mixing tank in order to avoid clogging of the filter surface. It was also pointed out that the study was done with a rapid mixing tank when the current trend in practice is the use of in-line mixers.

C. Paper No. C-91: "Management of Urban Waste Water Physico-Chemical Treatment Stations: Servocontrol of Reagent Additions at the Quiberon Sewage Treatment Plant, France" by P. Marchandise, J. P. Legendre, D. Delacroix, and J. L. Rivoal (France)

This paper presented the results of a project demonstrating the effectiveness of using continuous flow and turbidity measurements to control the automatic addition of iron salts at a full-scale sewage treatment plant. The past practice of overdosing had resulted in undersirable iron deposits. Turbidity was used as a surrogate parameter for both COD and suspended solids concentrations. The results showed that the automatic control system was effective in maintaining effluent quality while significantly reducing chemical costs.

The first issue discussed was the variation in dosage as as function of COD. A rearrangement of the jar test data was presented which indicated lower doses might be appropriate. It was also pointed out that the detention time in the jar tests was different from those at the full-scale plant. The objective used in setting doses was also questioned. It might have been more economical to meet a specified level of treatment instead of achieving the best effluent quality possible. The author responded that, in general, the public wants the cleanest water possible. The increased cost, however, was not quantified.

Another issue raised was the applicability of using turbidity as a surrogate parameter. How good are turbidity measurements for determining the removal of heavy metals and coliforms? This issue was unresolved because these parameters were not a major concern at this plant. Another discusser pointed out that work at the Newcastle plant in the United Kingdom has had success using oxidation-reduction probes for controlling addition of iron salts. The author responded that turbidity monitors were simple to operate and that he had no experience with the use of redox probes.

D. Paper No. C-92: "Modeling of the Coagulation-Adsorption Process in Treatment Systems" by A. M. Dziubek and A. L. Kowal (Poland)

The paper presented the development of a multilayer adsorption isotherm which can be used to describe the adsorption of total organic carbon on precipitates formed during coagulation processes. The model accounts for the presence of nonadsorbable organics and was verified with experiments using lime as the coagulant. Unfortunately, the authors did not appear to present the paper, and there was no nominated discusser.

E. Paper No. C-93: "Hexavalent Chromium Removal from Drinking Water" by J. M. Philipot, F. Chaffange, and J. Sibony (France)

This paper presented the results of pilot-plant studies designed to develop a treatment system for removing hexavalent chromium from a polluted groundwater. A number of processes were examined with the final selection being ferrous sulfate addition followed by sand filtration. The major concern was the oxidation of excess ferrous ion without reoxidizing the trivalent chromium formed. A filtration rate of 15 m/h with a 0.40-mm sand was found to produce satisfactory residual iron concentrations. It was speculated that a combination of chemical and biological mechanisms was responsible for removing the excess iron in the filters.

The discussion centered on two issues. The first was the effect of pH on the process. pH is known to effect the reduction of Cr(VI) to Cr(III), the formation of hydroxide precipitates, and the adsorption of hydroxides onto solids. The author responded that an optimal pH was not sought because adjusting the pH would require more chemical additions and increase the cost of treatment.

The second issue was the optimal conditions for bacterial oxidation of ferrous ion in the filter. If the redox potential dropped enough, iron could be reduced instead of being oxidized, and thus the effluent iron concentration could increase. The author responded that no attempts were made to differentiate between biological and physical-chemical mechanisms in the filter. The objective of the project was to develop a satisfactory process as fast as possible, and little time was available for theoretical studies. The significance of each mechanism was not clearly delineated and further research is necessary.

4. CRITIQUE OF SESSION

The papers presented varied greatly in approach and quality. Paper No. C-89 was of good quality and should be viewed as an excellent first step in examining the role of mass transfer in the design of ozonation processes. Paper No. C-90 was an empirical study showing the importance of rapid mixing on flocculation processes. The quality of the paper was questioned because the chemistry of the reactive species was not considered. Paper No. C-91 was strictly a case study showing the value of flow-proportional chemical dosing. Paper No. C-92 was of good quality and should be considered in the modeling of organics removal by adsorption on precipitates. The derivation of the BET equation with a nonadsorbable organic component is of good academic value. Paper No. C-93 was essentially a treatability study examining methods of chromium removal. This paper yielded good results and also raised several fundamental questions concerning the removal of chromium by ferrous sulfate addition.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The direct application of these papers to U.S.A. water pollution problems is somewhat limited. Several of the papers, however, pertained to current U.S.A. problems, and suggested that further research be conducted. Paper No. C-89 is of value because ozone is one of the disinfection methods being investigated to avoid trihalomethane production. The paper suggested that further research examining the role of mass transfer in ozonation processes be conducted. Paper No. C-90 is of value because rapid mixing and flocculation operations are used in most U.S.A. water treatment plants. The discussion suggested that research be conducted to develop practical design procedures based on a theoretical framework which includes the chemistry of the reactive species. Paper No. C-92 is of value because of the concern with the presence of trace organics in drinking water supplies. The paper suggested that further experimental work be conducted examining the removal of organics by precipitates formed during coagulation. Finally, Paper No. C-93 was of value because of the present concern over groundwater contamination. The discussion suggested that research examining the fundamental mechanisms involved in the removal of hexavalent chromium from water by ferrous sulfate addition be conducted.

1. SESSION

A. Day: Thursday, September 20, 1984
Location: Hall 3
Time: 9:00-10:45 a.m.

B. Theme of Session: Effects of Agriculture on Water Quality

2. REVIEWER

A. Name: E. Robert Baumann

B. Position and Affiliation: Anson Marston Distinguished Professor in Engineering, Professor of Civil Engineering, Iowa State University, Ames, Iowa (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

A. Paper No. C-94: "The Contribution of Agricultural Loading to Eutrophication in Finnish Lakes" by L. Kauppi (Finland)

Kauppi (Finland) described results of a study whose primary objective was to improve the basis for assessing the significance of agricultural nutrient loadings on the deterioration of fresh waters in Finland. Agriculture involves only 9% of the total surface area of Finland and only 30% of the surface area in the most intensely cultivated areas. Farm size is approximately 10 ha, and most are privately owned. Point sources of P and N are under environmental control. However, fertilizer use has doubled from 1960 to 1980 to a level of about 160 kg/ha-y. Estimates of nutrient losses from agricultural fields (1% and 13% for P and N, respectively) were based on study of small hydrological basins. Kauppi (Finland) calculated the dependence of P and N loads on the percentage of agricultural fields (FP,%) as: P-load (kg/km^2-y) = 15.1 $\log_{10}$ (FP+1) + 1.9; and N-load (kg/km^2-y) = 9.8 FP + 180.

The CREAMS (Chemicals Runoff and Erosion from Agricultural Management Systems) model developed by the U.S.A. Department of Agriculture was used to describe processes associated with nutrient losses. Simulation of monthly and annual runoff values was successful, but soil and nutrient losses calculated from the model deviated considerably from observed values. In principle, the CREAMS model seemed to be potentially suitable for estimation of agricultural pollution in Finland if its use is restricted to field scale. Model parameters, however, are many and reliable values for many are hard to determine.

Phosphorus is the primary limiting nutrient in Finnish lakes. Phosphorus transported by soil particles is often the most important component of non-point P loading of lakes, yet algae utilize P in a soluble form. Laboratory studies indicated filtration of runoff water to remove adsorbed P decreased algal growth potential (AGP) by 5 to 82%. Kauppi (Finland) suggested that algae are not needed to enhance desorption by removing P from solution; that is, it appears that chemical desorption would account for the transformation of P into a bioavailable form.

Vinken (The Netherlands) indicated that control of point sources of pollution in Finland and many other countries is not enough to halt eutrophication of fresh waters. Since non-point-source contributions of N and P are sufficient to continue eutrophication, P present in sediments becomes available for many years. Soil losses due to runoff and sedimentation in lakes can supply P for long periods after P and N contributions are ended.

Isgard (Sweden) indicated that similar agricultural runoff problems exist in Sweden. However, for fertilizer applications under 100 kg/ha, the pollution runoff from agriculture is not significant. Over 100 kg/ha, fertilizer pollution becomes significant and an environmental surcharge is assessed to reduce excess fertilizer use. This agricultural pollution and acid rain are the two major environmental problems in Sweden. Baumann (U.S.A.) pointed out that in Iowa, agricultural runoff contributes more than 90% of pollution in Iowa's rivers, with many rivers carrying 0.5-2.0 mg/L of P and nearly 10 mg/L of nitrate-N. The trend to minimum tillage seems to have increased some contributions of pollutants.

Kauppi (Finland) indicated that it did not appear possible to reduce the 1% loss of P from fertilizer to streams and lakes. Fertilizer use in Sweden and Finland is similar. In Finland, the interest is in holding P levels to µg/L-levels.

B. Paper No. C-95: "Modeling Water Quality and The Effects of Agricultural Best Management Practices in the Iowa River Basin" by B. R. Bicknell, A. S. Donigian, Jr., and T. A. Barnwell (U.S.A.)

Barnwell (U.S.A.) described the use of mathematical models to analyze and predict the quantity and quality of runoff from agricultural lands. The ultimate goal is to use such models to develop a Best Management Practice (BMP) that will minimize water quality impacts while maintaining agricultural land productivity. The paper described a study of the Iowa River Basin which included application and evaluation of the Hydrological Simulation Program - Fortran (HSPF) to both the data-intensive Four Mile Creek watershed and the Iowa River above the Coralville Reservoir. The methodology developed on Four Mile Creek was extrapolated to the Iowa River Basin to demonstrate its applicability and functionality on a large river basin. Some model parameter values from the small basin were applied directly to the larger study area without adjustment while other parameters were modified, based on available information and model calibration to the larger basin. The study was used to explore the problems associated with modeling the hydrology, sediment, and chemical fate and transport in a large basin with varying meteorologic conditions, soils, and agricultural practices.

The Iowa River study basin has an area of 7,240 km_2. The basin was divided into three segments to perform a reasonable hydrologic simulation. The three segments were then divided into previous land segments (PLS's) based on land use (65%-85% in cropland). The river was also divided into 13 reaches based on physical considerations for simulation.

A limited hydrologic/hydraulic simulation was conducted to demonstrate sufficient agreement between model and field data results to justify use of the model for BMP analysis and evaluation. Then, both sediment and nutrient simulations were performed. The simulation of flow frequencies on the main stem of the river were fair to good; sediment simulation was poor due to insufficient calibration, lack of data, and model deficiencies. Pesticide/herbicide and nutrient loadings were usually within the range of observed field grab sample data.

The principle BMP components evaluated were: shift from moldboard plowing to chisel plowing; one summer cultivation for weed control instead of two; and allowing crop residues to remain on the field following harvest. The model indicated that such practices would reduce runoff (6-8%), sediment (33-45%), alachlor (19-30%), nitrate (3-5%), and ammonia (23-28%) in the river depending on whether corn or soybeans were the principle crop.

The study indicated that the HSPF model, with proper calibration, offered a flexible and realistic means of approximating the quality/quantity impacts of BMPs in large river basins.

Kauppi (Finland) indicated that the HSPF model did not provide good representation of the sediment loads and asked whether this was the fault of the model or the adequacy of the field data. Isgard (Sweden) wanted to know whether BMP's were related to enforcement or only a recommendation. Ives (United Kingdom) asked about the size of the computing facilities needed and whether the size was related to the complications of the model or the requirements of the river basin system. Chutter (South Africa) noted that the inaccuracies in modeling sediment transport indicated that there would be similar inaccuracies with modeling phosphorus transport which was not modeled in the study.

Barnwell (U.S.A.) concluded that the errors related to sediment were related, unfortunately, to the model and not the data from the field. The problem may be due to the fact that much of the sediment is due to bank erosion and not sheet erosion. BMPs really refer to what the agricultural community will recommend to farmers. BMP does not refer to any enforcement legislation, though it may be recommended by government agencies. Computer needs are related more to the basin reaches and complications needed and not the model. The Hewlett-Packard 1000 is the smallest computer the model has been run on; it takes about 12 hours. On a large IBM main frame, a similar run takes about 5 minutes.

C. Paper No. C-96: "Surface Water Quality in Relation to Soil Type, Land Use and Discharge in a Rural Catchment Area" by M. C. H. Witmer (The Netherlands)

Witmer (The Netherlands) described a study to evaluate surface water quality and the factors that influence that quality in a rural area in The Netherlands lying between an ice-pushed ridge and river backlands. The type of soil, the land use, and vegetation all influence water quality directly by surface runoff or indirectly by groundwater flow. Recent attention has focused on non-point pollution sources because: (1) Such pollution is difficult to control since it is the cumulative effect of many spatially scattered activities which make it difficult to implement technical controls, and (2) The processes involved in the diffusion of non-point pollution are usually slow. When surface effects show up, a large area may already be contaminated. The Langbroek drainage basin is a priority national landscape, and no activities will be permitted to affect its historical and natural values. Accordingly, soil, vegetation, and land uses have been classified and mapped. Research focused on nutrient transport by flowing water within and between ecotypes defined as spatially basic units that are internally homogeneous in all ecologically important properties.

Surface water studies were conducted with sampling at three levels: the ecotype level (ditches draining plots with one soil type and one soil use); the transect level (canals draining different soil types and land uses); and the output level (discharge measured at two outputs of the basin). Both base and peak flow conditions were monitored.

Results for the ecotype level indicated that nutrient contents in ditches increased with intensity of cultivation on sandy soils; but not on clayey soils, due to the higher adsorption capacity and low drainage velocities. Transect sampling provided a similar result. High concentrations of orthophosphate correlated with a high density of cottages along a canal or stream. Base-flow water quality was greatly affected due to the impact of manuring and fertilizing on sandy soils. If eutrophication of the canals was to be arrested, the use of manure and fertilizer should be limited, especially on sandy soils. Household wastes must be discharged outside the basin to lower the orthophosphate levels. Under peak flow conditions, runoff of nutrients occured from both sandy and clayey soils having both relatively natural vegetation as well as intensely cultivated operations. The effect of runoff on potassium and nitrate on surface water quality exceeded the dilution by rainwater. This is not so for sodium and chloride.

Afifi (U.S.A.) indicated that sampling of the 2300-ha basin was intensive and adequate to evaluate the water quality and the factors contributing to it. She questioned the effects of sandy and clayey soils on contributions to pollution, since soil use was not common to both. The role of peat was not discussed with regard to water quality. Wheatland (United Kingdom) pointed out that during long drought periods in England, nitrate levels in the Thames River reached nearly 50 mg/L (as nitrate), the upper WHO limit for drinking water. The hypothesis was that the organic nitrogen in the soil was mineralized during the long period of dry weather and that the rainfall then flushed out the mineralized nitrate. Witmer (The Netherlands) supported this hypothesis, but indicated that the question was not addressed in her studies.

4. CRITIQUE OF SESSION

The papers in this session concerned the contributions from agricultural lands to the eutrophication of streams and lakes. Paper Nos. C-94 and C-96 were concerned with agricultural contributions to pollution in Finland and The Netherlands, respectively. Both papers indicated that, even with the elimination of point sources of pollutants, the streams, ditches, and canals adjacent to agricultural lands suffer from eutrophication. Phosphorus is the limiting nutrient in Finnish lakes and attention must be directed to control such contributions from agricultural operations. The Netherlands study (Paper No. C-96) indicated that normal flow contributions from sandy soils are far greater than from clayey soils. During peak surface runoff conditions, agricultural contributions from both sandy and clayey soils increased, but with greater increases from the sandy soils. Paper Nos. C-94 and C-96 were concerned mainly with identifying the effects of several factors which affect the nutrient/pollutant contributions from agricultural operations. Both assumed that point source contributions are already under control.

Paper No. C-95 was concerned with using data from small watersheds and from studies described in Paper Nos. C-94 and C-96 to provide inputs into mathematical models that can then be used to predict the impact of different agricultural practices on subsequent water quality. The studies described in Paper No. C-95 gave prediction results for flow, sediment transport, and nutrient transport that varied from poor to good. Sediment transport results were particularly poor and would seriously affect the ability to model phosphorus transport. This paper did, however, demonstrate that the model could predict the effect of agricultural operational changes on the level of agricultural contributions to pollution. Studies such as those described in this session should be conducted to refine the mathematical models developed to evaluate land management effects on agricultural contributions and also to improve the accuracy of the effects of such land management. Until the error in predicting the effects of land management is less than the probable effects of that land management scheme, one cannot determine whether the variations in effect are due to normal errors in the model or an actual effect of the land management change. Until one has adequate models, one cannot design field experiments needed to define the data (e.g., exponents and coefficients) necessary to make effective use of the models.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

It would appear that the U.S.A. is rapidly approaching a time when a major change can and must be made in controlling agricultural use of land if the U.S.A. is to obtain the quality of water it seeks to achieve in its rivers and lakes. Both papers describing agricultural contributions to water pollution (in Finland and The Netherlands) indicated that one major control measure would be achieved by limiting the application of fertilizer to a level of 100 kg/ha. Sweden has assessed an environmental surcharge to those farm operations that exceed that level.

The studies in Paper No. C-95 indicated that we may be close to perfecting a model (HSPF - the Hydrological Simulation Program - Fortran) that will permit the development of waste load allocations for non-point sources of pollution. These could take the form of establishment of mandatory Best Management Practices for agricultural land, based on evaluation of the effects of such practices in each basin whose water quality requirements indicated the need for such controls.

1. SESSION

   A. Day: Thursday, September 20, 1984
   Location: Hall 3
   Time: 11:15 a.m. to 12:25 p.m.

   B. Theme of Session: Urban Runoff

2. REVIEWER

   A. Name: E. Robert Baumann

   B. Position and
   Affiliation: Anson Marston Distinguished Professor in Engineering, Professor of Civil Engineering, Iowa State University, Ames, Iowa (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

   A. Paper No. C-97: "Chronic Pollution of Intercity Motorway Runoff Waters" by J. D. Balades, M. Cathelain, P. Merchandise, J. Peybernard, and J. C. Pilloy (France)

Cathelain (France) described two studies of chronic pollution resulting from highway runoff on two highway sections having different hydrologic characteristics. One site was on the A 4 motorway near Metz. It was a straight 10.5-m wide section on a slope of 2.1% with a catchment area of 1,470 m^2. Only the pavement itself (0/14 mm bituminous concrete) was monitored. The road carried about 5,500 vehicles per day. The second site was on the A 61 motorway near Bordeaux. The catchment was 600-m long by 10.5-m wide. The pavement surface was cement concrete. The road carried about 7,000 vehicles per day.

Each site was equipped for flow measurement and automatic sampling of each runoff event with a number of samples taken during each event. Data collected included rain intensity, depth, flow rate, day-minute-hour of each event, and identification of each sample. Samples were analyzed for COD, suspended matter, lead, zinc, and hydrocarbons. The runoff was collected to provide methodology for estimating the annual pollution load.

The results were expressed in annual loads from the highways per km of two-lane highway. Annual loads of lead (0.43 - 1.2 kg/y) and zinc (1.23 - 2.3 kg/y) were proportional to traffic (5,400 and 13,600 vehicles. Annual loads of COD (231-392 kg/y), suspended matter (199-764 kg/y) and hydrocarbons (1.71 - 5.13 kg/y) were more related to type of catchment area and climate.

Study results were used to propose annual load range limits for motorway traffic ranging from 5,000 to 13,600 vehicles, a range of climates from semi-continental to oceanic, and a gasoline containing lead at 0.4 g/L: COD (230-400 kg/km), suspended matter (200-1200 kg/km), zinc (1.5-2.5 kg/km) and lead (0.9-1.3 kg/km). The load of lead was the only parameter considered to need action. Further study of the mobility and potential toxicity of lead and the relative importance of lead of highway origin in human accumulation were deemed necessary.

The manner in which pollution loads are entrained and the form in which they reach the environment are important. Two rains on one site carried more than 10% of the load contained in 112 events. Six events evacuated more than 30% of the COD and suspended matter loads.

Christensen (U.S.A.) raised a number of questions concerning the loads developed in the paper, pointing out that they may not consider loads of the pollutants contained in the precipitation. About 7.6% of lead discharged by traffic is deposited on the street; the rest is distributed elsewhere.

B. Paper No. C-98: "Collection and Analysis of Urban Runoff Data in Finland" by M. J. Melanen (Finland)

Melanen (Finland) described a three-year study of runoff from seven urban catchments in four cities. By 1980, over 70% of Finland's population of 4.8 million were served by public water pollution control plants. Separate sewers are dominant, and the uncertainty of pollution loads from urban runoff led to the study. At each catchment, rainfall was recorded with an accuracy of ±5 to ±15%. Daily and monthly air temperature and monthly wind speed used in the analyses were taken from the closest climatological stations.

An emission inventory (particulates, hydrocarbons, nitrogen oxides, oxides of sulphur, vanadium, cadmium, and lead) was performed at each catchment to provide local backgrounds. Aerial particle deposition was sampled monthly with an accuracy of ±50%.

Runoff was sampled by an automatic sampling device that provided a flow-proportional composite sample. The accuracy of the runoff quality data was estimated to be on the order of ±20 to 40%. Both parametric and non-parametric methods were used in the statistical analysis of the data generated.

Runoff events varied between 70 and 160 at each catchment. Runoff coefficients varied between 50 to 80% in residential areas and 80-90% in city centers and industrial catchments.

Study results indicated that average rates of deposition of components in urban catchments compared to non-urban regional background points are roughly 100% higher in the case of total organic carbon, 50-100% higher for total phosphorus, 50-200% higher for sulfate, but of the same order of magnitude in the case of total nitrogen.

A total of 30 physical, chemical and biological parameters of the runoff waters were measured. The quality of the runoff water cannot be generalized, but is dependent on local conditions. The mean suspended solids level was 250 mg/L, TOC was 18 mg/L, BOD (7-day) was 19 mg/L, COD was 150 mg/L, total P was 0.35 mg/L, total N was 1.9 mg/L, chloride was 4.8 mg/L, sulphate was 30 mg/L, vanadium was 0.019 mg/L, zinc was 0.36 mg/L, copper was 0.079 mg/L, lead was 0.22 mg/L and the median pH was 6.8. The variance of the quality parameters was very wide with standard deviations on the order of 50-100% of the arithmetic means.

Analysis of the data of the quantity and quality of urban runoff waters indicated that, under Finnish conditions, loads of organic matter and nutrients are relatively minor in comparison to those of purified wastewaters. Accordingly, it was suggested that further measures be focused on increasing the effectiveness of Finland's 560 treatment plants and decreasing the leakage inflows to the sewer systems rather than seeking to control urban runoff.

Preul (U.S.A.) indicated that Finland is fortunate to have mainly separate sewer systems. The average Finnish rainfall is 50-70 cm/y, much lower and much less intense than typical rainfall in the U.S.A. Therefore, extrapolation of Finnish urban runoff data to the U.S.A. would not be applicable. The maximum values of water quality parameters are about five to six times the mean values cited earlier. He questioned if the maximum values could be ignored even though, on the average, mean values were at appropriately low levels. From a public health viewpoint, data on total or fecal coliform levels would always be of interest in a study such as this.

Melanen (Finland) indicated that colleagues in Sweden, Norway, and Canada have reported parameter values in the same order of magnitude found in the study. Cathelain (France) supported the techniques used and believed the results were applicable in Europe; they are similar to parameter magnitudes reported in France. Bryant (U.S.A.) noted that the conclusions from this paper are directly contradictory to results he obtained in studies in Michigan eight-ten years ago.

4. CRITIQUE OF SESSION

The two papers in this session vary in scope and interpretation. Both contained much data which were not generally pertinent to U.S.A. conditions and which would be difficult to extrapolate to U.S.A. conditions. Paper No. C-97 measured highway runoff only from the travelled portion of the highway and did not detail to any significant extent how the results can be used to generate total pollutional loads from highways. Paper No. C-98 dealt with determination of runoff water quality parameters from urban areas in a country and climate that are unique and different from U.S.A. conditions. Therefore, extrapolation of mean and maximum parameters from storm flow-proportional composites would be difficult and unwarranted. In spite of indications by Melanen (Finland) and Cathelain (France) that the data presented were similar to those obtained in Sweden, Norway and France, it would appear that U.S.A. data would more probably be similar to that described by Bryant (U.S.A.).

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The papers in this session covered areas that are currently under study by State Department of Transportation or that were covered by cities and the EPA about five to ten years ago. The techniques of data collection and analysis are not new and the studies do not appear to be particularly applicable to U.S.A. conditions.

1. SESSION

A. Day: Thursday, September 20, 1984
Location: Hall 3
Time: 2:00-4:20 p.m.

B. Themes of Session: Marine Wastewater Disposal and Standards; Transport and Processes in Sewers

2. REVIEWER

A. Name: Boris M. Khudenko

B. Position and Affiliation: Associate Professor, Georgia Institute of Technology, Atlanta, Georgia (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

A. Paper No. C-99: "Marine Quality Standards: Their Derivation and Application in the United Kingdom" by G. Mance and A. R. O'Donnell (United Kingdom)

Mance (United Kingdom) discussed the derivation of environmental quality standards for coastal waters and the difficulties of using such standards for controlling industrial discharges. Attention was focused on the common List II substances (copper, chromium, lead, nickel, zinc, and arsenic) and their effect on marine life. The List II, established by the Council of European Communities Directive on the Dangerous Substances Discharge (1976), includes the substances which must be reduced, while List I compiles the substances which must be completely eliminated. The adequacy of existing toxicity data was discussed, and it was concluded that long exposure tests were required to provide information on sublethal effects. Such data are currently limited. It is also important that consideration be given to the effects that reducing salinities and increasing temperatures have in increasing the toxicity and to the difficulty of toxicity evaluation and the data interpretation.

The discussion centered on the comparison of the end-of-pipe and ambient standard requirements and the evaluation of procedures used in the United Kingdom for establishing their present standards. Regarding the standards comparison, discussers pointed out the difficulties in monitoring and enforcement procedures for the ambient standard, and also in evaluating the initial mixing zone. Concerning the United Kingdom standards, discussers stressed two points; first, the procedures used in the U.S.A. (California) have more sound scientific ground, and second, the end-of-pipe discharge requirements derived on the basis of the United Kingdom ambient standards are less stringent than in the rest of Europe.

Mance (United Kingdom) argued that only ambient standards insure environmental safety and permit an intelligent determination of individual end-of-pipe discharge requirements. He also referred to the similar approach used in the USSR. Regarding the toxicity evaluation procedures he maintained that, in spite of all uncertainties involved, the United Kingdom uses the most appropriate method.

B. Paper No. C-100: "The EEC Shellfish Directive in Wales" by S. N. Young and P. Wathern (United Kingdom)

Young (United Kingdom) discussed details of the procedures adopted by the United Kingdom in implementing the EEC shellfish directive and a review of the water quality monitoring programs used by the Welsh Water Authority with respect to these provisions. Six shellfish beds were surveyed in detail by the Authority, and only one met the standards. Meeting the required standards at other shellfisheries would involve considerable capital expenditures, mainly for sewage treatment. The United Kingdom government precluded such expenditure, since it has claimed that any public health measures inherent in the directive were covered adequately by current practices. This paper highlighted potential problems resulting from conflict between international and national water quality priorities.

Floor discussers agreed with the findings presented in the paper and stressed that United Kingdom practices deviate from the EEC directive resulting in substantial water pollution and public health risk. The problem was attributed to the current economic state in the country.

C. Paper No. C-101: "Operation and Efficiency of Automatically Operating Weir Structures--A Contribution to Cleaner Waters" by E. Macke (Federal Republic of Germany)

Automatically operated weir structures were developed and tested in several large cities in the Federal Republic of Germany. The goal of these developments was to maximize the storage capacity of combined sewer lines, so that the maximum impounding level is reached not only in the event of the maximum probable (design) flood but at any sufficient flood event. This reduced overflow occurrences and the quantities of overflow discharged to a water body reducing the pollution of natural waters. The maximum impounding level was determined to assure that the sewer did not overflow onto the streets.

Two types of automatic weir structures were described: a structure with a float-driven mechanical shutter located above the weir crest, and a syphon structure with the air-controlled flow rate wherein an automatic air valve is located on the syphon top and the air flow is regulated by a float. Both weir types were composed of multiple sections which can often be installed in existing sewers. The structures were simple and largely maintenance free. Substantial economic advantages were realized through reduction or complete elimination of the special wastewater storage tanks or trunks.

Discussion focused on the applicability of the proposed structures to small rural and urban sewer systems, the putrefaction processes in the backwatered sewers, reliability of these devices, and cost benefits. In his reply, Macke (Federal Republic of Germany) stated that the applicability of the device must be determined for each site. He did not have any data on the putrefaction. The system was found reliable in operation, and considering the use of multiple units, no high malfunction risks were expected. The system cost is usually in thousands DM, while the savings through dispensing the special storage tanks are in millions DM.

D. Paper No. C-102: "Sedimentation, Mineralization, and Resuspension of Sludge in a Sewerage System: A Case Study" by A. S. Hogendoorn-Roozemond (The Netherlands)

Quantitative information was obtained on the processes of sedimentation, mineralization and resuspension of organic matter in a combined sewerage system by means of statistical analysis of dry and wet weather data on sewage flows and water quality. The effects of temperature and length of intermittent dry weather periods on daily pollutant loads were also evaluated. For the sewerage system investigated, it was found that in summer, 5-26% of the BOD produced is mineralized in the system before reaching the sewage treatment plant. Due to sedimentation under dry weather conditions, up to 12% of the daily organic load produced may be present in the sewers as resuspendable deposits; in winter this percentage may amount to 20-30% because of slow mineralization.

In his final remarks, the author pointed out that the quantitative data obtained in the case study was site specific. It was, therefore, recommended that similar statistical investigations should be carried out for other sewerage systems. This will provide quantitative information and further insight into the individual combined sewer overflow pollution loads. Optimization of sewer system designs would then be possible, enabling a cost effective water pollution abatement strategy.

In addition to the information presented in the paper, the author said that automated data acquisition systems are being installed in several municipalities in The Netherlands. This will provide a better data base for evaluating the processes in sewers.

Floor discussers agreed that this problem is important for low slope sewers with less than self-cleaning velocities in dry weather.

4. CRITIQUE OF SESSION

Paper Nos. C-99 and C-100 related to marine wastewater disposal. Paper No. C-99 reintroduced the discussion on the priority of either ambient environmental standards or effluent (end-of-pipe) standards. From a philosophical point-of-view, the ambient standard seems to be more logical. However, the insurmountable difficulties in determination of standard values and in evaluation of spacial and temporal distributions of pollutants preclude rigorous computations of effluent requirements, thus leaving room for voluntaristic discharge requirements. It is obvious, and it was stressed by discussers from France, that the major reason for the United Kingdom deviation from EEC directives is the current economic state which demands the relaxed discharge requirements. The reference to the Soviet ambient standard did not prove the validity of the British approach, but rather confirmed its disadvantages. From the writer's experience, the Soviet enforcement agencies are almost always overruled by other offices by promising to reallocate the pollutant loadings among dischargers. However, this often happens too slowly, and this paper raised more questions than it brought useful solutions.

Paper No. C-100 was a site-specific case study with limited value for other sites. This paper confirmed the disadvantages of the United Kingdom policy of not accepting the EEC directives and using the ambient standards as the basis for establishing the discharge requirements.

Paper Nos. C-101 and C-102 were devoted to processes in combined sewer overflow systems. Paper No. C-101 was focused on tools for hydraulic optimization of sewers and reduction of the untreated overflows, while Paper No. C-102 discussed the dynamics of pollutant sedimentation, partial decomposition, and resuspension in conjunction with dry weather and rain flow variations. Analysis of these papers shows that potential exists for pollutant loading rate reduction on treatment plants and on receiving waters by controlling the conversion processes and hydraulics of sewers. Although such a marriage was not considered at the session, it should be pursued in the future. In addition to the questions discussed in the session, the possibility of permanent deposits in low slope or backwatered sewers, the need for efficient network ventilation, and in-sewer flow and concentration equalization should be considered.

In view of the broader application of ideas and results reported in Paper Nos. C101 and C-102, these papers can be considered as pioneering studies which eventually can result in substantial economic benefits and environmental quality improvements.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

Paper Nos. C-99 and C-100 did not present ideas or data valuable for the U.S.A. research program.

Paper Nos. C101 and C-102 can be considered as new steps toward the development of in-sewer control means for improving the economic characteristics and the stability and performance of wastewater management systems. Although substantial work in this direction has been recently performed in the U.S.A., additional research and development toward more active in-sewer controls should be considered.

1. SESSION

   A. Day: Tuesday, September 18, 1984
      Location: RAI Conference Center, Hall 9
      Time: 4:15-6:00 p.m.

   B. Theme of Session: Implementation of Research Needs

2. REVIEWER

   A. Name: E. H. Bryan

   B. Position and Affiliation: Division of Civil and Environmental Engineering, National Science Foundation, Washington, D.C. (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

In a special session, Engelbrecht (U.S.A.), President of the IAWPRC, presided over a panel discussion on the topic of the administration of research programs. Panelists were Bryan (U.S.A.), U.S. National Science Foundation; DiGiano (U.S.A.), representing the Association of Environmental Engineering Professors; Ives (United Kingdom), University College London and current Executive Editor of Water Research; Elmaleh (France), Universite des Sciences et Techniques du Languedoc; Odendaal (South Africa), Water Research Commission; and Robel (Federal Republic of Germany), Water Technology Project Agency. Each panelist described the process by which research needs relating to water problems and potential performers of research are linked in their respective countries, how research needs are identified and prioritized, and methods for dissemination of the results of research.

Bryan (U.S.A.) emphasized the roles of individual investigators in proposing projects for support and that of peer reviewers, external to the National Science Foundation, in guiding the decision regarding selection of projects for support. Investigators are encouraged to publish their findings in the open, scientific and technical literature and any final reports received are made available to the public through the National Technical Information Service, U.S. Department of Commerce. Coordination of research and assistance in identification of research needs are accomplished by support of conferences and workshops.

International cooperation that promises significant benefit to U.S.A. science and engineering is encouraged through formal, bilateral programs and by ad hoc arrangements between U.S.A. and foreign institutions on behalf of investigators who apply for support through their own respective funding agencies.

DiGiano (U.S.A.) reviewed the process that led to a conference supported by the National Science Foundation on Fundamental Research Needs for Water and Wastewater Systems, held in December of 1982 in Washington, D.C. He emphasized the significant role played by representatives from industry, consulting engineering firms, and the cooperation of the U.S. Environmental Protection Agency in the structuring and conduct of this conference and announced the current availability of its Proceedings from the Association of Environmental Engineering Professors (c/o D. F. Lawler, Department of Civil Engineering, University of Texas, Austin, Texas 78712, U.S.A.).

Ives (United Kingdom) described the process by which research funds are allocated to the research community in the United Kingdom, noting that the principal funding agency is the Science and Engineering Research Council (SERC) which provides grants to universities and polytechnics based on proposals responding to special announcements or upon the initiatives of the investigators. Funds provided through these grants may be utilized for the usual costs of conducting the research, except for academic staff salaries and institutional overhead--cost items that are provided for within the British concept of "dual support," viz. regular direct funding for universities already includes funds for conduct of both teaching and research, and research is expected of all academic staff. British universities may contract with government agencies, water authorities, and industries for conduct of research. Some support for research is also provided from private foundations. International collaboration with SERC funds may include short visits by United Kingdom scholars to other countries and provide for the support of visits of up to one year in duration by foreign academics to British universities and for research by British scholars in selected developing countries.

Odendall (South Africa) noted his country's emphasis on applied research, funds for which are obtained by a special tax levied on consumption of water. The Commission only engages others to conduct research through contractual arrangements that are closely monitored. The concept of technology transfer is strongly encouraged, the strategy for which is by encouragement of user involvement in all phases of the research. This is accomplished through formation of user committees relevant to each project receiving support. Special attention is given to production of publications that present results from research projects in a manner that relates those results to user needs. The Commission also provides support for demonstration projects.

Elmaleh (France) emphasized the role of industry in supporting research on water issues in France. Pollution fees and fines are used to finance both the construction of pollution abatement facilities and for support of research. He also mentioned that much of the water-related research is conducted by personnel employed by ministeries on problems relating to their functional mission responsibilities.

Robel (Federal Republic of Germany) presented an overview of research project support procedures used by the Nuclear Research Center at Karlsruhe. Projects at universities are fully supported while research conducted by industries and municipalities receive only one-half of the necessary funds from his agency for conduct of projects proposed and accepted for funding. He pointed out that, being a small country, German researchers are generally aware of problems that require research and about research being conducted by their professional colleagues. He stressed the role of his Center in obtaining cooperation of scientists in government, industry and at universities by distribution of projects lists and the publication of final and special reports, the quality of which is achieved by a system of peer review. He also mentioned international cooperation through bilateral arrangements with selected countries for exchange of experiences, results of research projects, and development of research needs.

Audience participation followed presentations by the panelists. A significant issue emerging from this discussion was concern that unconventional, "far-out" concepts of merit might not receive deserving support as a consequence of the peer review processes that seeemed generally common among all programs described by the panelists.

1. SESSION

A. Days: September 17-20, 1984
Location: RAI Conference Center
Amsterdam, The Netherlands

B. Theme of Poster
Presentations: Anaerobic Treatment; Water Quality Modeling; Wastewater Treatment in Fluidized Beds

2. REVIEWER

A. Name: Joseph F. Malina, Jr.

B. Position and
Affiliation: C. W. Cook Professor of Environmental Engineering, Chairman of the Civil Engineering Department, The University of Texas at Austin (U.S.A.)

3. DESCRIPTION OF POSTER PRESENTATIONS

A. Poster No. P-8: "A Fixed Bed Reactor and Stirred Reactor Compared in the Case of Anaerobic Wastewater Treatment" by S. Kunst and K. Mudrack (Federal Republic of Germany)

A fixed bed reactor and a stirred reactor with a secondary clarifier were used to evaluate the anaerobic treatment of a wastewater containing pectin at 35°C. The hydraulic detention time was three days in the stirred reactor and one day in the fixed bed reactor. The fatty acid concentration reached 2000 mg/L at organic loadings of 2.11 g COD/L-d and more than 5 g COD/L-d in the stirred reactor and fixed bed reactor, respectively. The major difference between the two systems is that methane-forming organisms developed in the fixed bed reactor but did not develop in the stirred reactor. In fact, methane was produced in the fixed bed reactor at an organic loading of 6.3 g COD/L-d and at a pH of 3.4. The gas contained 31% methane, although the gas production decreased. The major advantages of the fixed bed reactor included: suitability as a methane generator in a single- or two-phase system; retention of slow-growing methane forming bacteria; and simultaneous existence of organisms with different environmental requirements such as pH and substrate. A major disadvantage cited was the inability to maintain the fixed bed reactor as an acidification unit without losing methane generated by the methane organisms which develop in the fixed bed. The major advantages of the stirred reactor included: suitability as an acidification unit at high organic loads; and recycling of the effluent permits pH control and influent dilution at high organic loadings. The major disadvantages are the stirred reactor is not suitable for operation as a single-phase methanogenic unit at high organic loadings; and microorganisms are lost from the system.

B. Poster No. P-15: "Center for Water Quality Modeling" by T. Barnwell (U.S.A.)

The poster described the functions of the Water Quality Modeling Center and the interaction among model users, model developers, and the staff at the Center. Emphasis was placed on the feedback system involving the model developer, the users and the staff. Models are refined through incorporation of modifications. Enhancement of the water quality models is based on selection criteria such as utility and effectiveness, adequacy of documentation, user acceptance, and staff experience. The Center maintains models which can be used for screening analysis, detailed analysis, water quality assessment, water quality modeling, storm water management, water analysis simulation, and chemical transport and fate of toxic materials.

C. Poster No. P-29: "Biological Treatment of Phenolic Wastewater in a Three-Phase Fluidized Bed" by Y. Hosaka, M. Kaihou and A. Hirata (Japan)

The three phases of this process include: small particulate media, attached biofilm and air which is used to fluidize the media. The apparatus was a column (5 cm in diameter and 327 cm tall) in which air was introduced at the bottom and a mechanical stirrer, located in an expanded section at the top, was used to insure mixing and suspension of the media. The solids in the effluent of the reactor were separated in a settling tank. The media used include: activated carbon (0.458 mm), cement balls (fly ash with cement binder) (0.83 mm), toyoura sand (0.074-0.42 mm) and quartz sand (0.38 mm). Preculture was required to develop suitable biological growth on the activated carbon, toyoura sand, and quartz sand. The cement balls provided the most stable operation and were easily mixed even without mechanical stirring. There was no significant difference in phenol removal rates among the media except for the quartz sand. The maximum phenol removal rate was 2.43 to 4.80 kg/m^3-d at an influent phenol concentration of 30 mg/L. At these loadings, effluent phenol concentration was essentially zero. However, removal of phenol was only 60% to 70% at influent phenol concentrations of 62 to 115 mg/L.

4. CRITIQUE OF SESSION

The three poster presentations varied in the detail and significance of the data presented. In the case of Poster No. P-8, the hydraulic detention time in the stirred reactor of three days was considerably lower than one might expect to use for effective methanogenesis in anaerobic systems. Typical minimum solids retention times usually are about 7 to 10 days. Therefore, it is not surprising that no methane gas was produced. The fixed bed reactor had only a one-day hydraulic detention time; however, there is no information regarding the estimated sludge age of the biomass attached to the media.

Poster No. P-15 illustrated the functions of the Center for Water Quality Monitoring and the various water quality models which were maintained by the Center staff. These models were developed through the efforts of the Center from the model developer and enhanced and refined by the model users.

In Poster No. P-29, the concentrations of phenol that were used were relatively low; however, the authors attempted to extrapolate the performance of the system for design purposes to influent phenol concentrations which exceeded 1,000 mg/L, although the experimental influent data ranged from approximately 30 mg/L up to about 113 mg/L. At the low concentrations, complete removal of the phenol is possible; however, at concentrations in excess of 30 mg/L effluent phenol, concentrations ranged from about 36 mg/L to over 80 mg/L as the influent concentration was increased to 62 mg/L and 115 mg/L, respectively.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The two poster presentations dealing with aerobic and anaerobic biological treatment have minimal application or significance to U.S.A. water pollution control research efforts. The anaerobic studies reported on phenomena which already have been published in the technical literature. Anaerobic treatment of industrial wastes at equally high concentrations as the pectin wastewater is quite common throughout the world. The three-phase fluidized bed system may have applicability for different industrial wastes, but the experimental procedures and operating conditions must be defined in much more detail. The Center for Water Quality Modeling is a U.S.A. operation that focused on updating and maintaining current versions of water quality models and has expanded into the chemical transport and fate of toxic materials.

1. SESSION

A. Days: September 17-20, 1984
Location: RAI Conference Center
Amsterdam, The Netherlands

B. Theme of Poster Presentations: New Approaches to Sludge Disposal, Sludge Separation and Algal Production Potential

2. REVIEWER

A. Name: Judith B. Carberry

B. Position and Affiliation: Associate Professor, Department of Civil Engineering, University of Delaware, Newark, Delaware (U.S.A.)

3. DESCRIPTION OF POSTER PRESENTATIONS

A. Poster No. P-7: "Evaluation of a Sludge Treatment Process for Thermal Conditioning" by L. Spinosa (Italy)

This poster displayed the results of laboratory tests used to precondition sludge for dewatering and incineration. The process included the following steps: heating; conditioning; thickening; pressure filtration; and incineration.

The experiments utilized a 4-L reactor for heating the sludge at 200°C for one hour. The sludge was then pressure-filtered in a 165 m^3 chamber at 8.5 kg/cm^2. Filtration times of 0.5 and 1 h produced solids concentrations of 50% and 59%, respectively.

The following thermal balance was calculated from the experimental results: required fuel = 4000 $kcal/m^3$; recovery from sludge cooling = 161,000 $kcal/m^3$; recovery from incineration = 10,000 $kcal/m^3$; and recovery from anaerobic digestion supernatant = 11,000 $kcal/m^3$.

B. Poster No. P-11: "New Design Guidelines for Circular and Rectangular Final Settling Tanks" by R. Epskamp and F. Hernen (The Netherlands)

The authors observed solids profiles at variable surface overflow rates, solids concentrations, and settling velocities in 48 circular clarifiers and in 27 rectangular sedimentation tanks. They drew correlations between sludge volume (mL/L) vs. q, the surface overflow rate (L/m^2-h). They found that the data fit three types of curves, so they used these correlations to set up an algorithm for designing settling tanks. The resulting maximum surface overflow rate provided the values necessary to compare the allowed storage capacity to the required storage capacity of the tank design. A flow chart of the algorithm was illustrated.

C. Poster No. P-14: "Algal Growth Potential Test: An Indicative Method to Estimate the Influence of Water Quality Changes on the Algae Biomass" by G. Bolier (The Netherlands)

The author developed a procedure to measure algal growth potential (AGP) using the test species, Scenedesmus quadricauda, because of its wide range of sensitivities. The sample handling procedure was standardized by autoclaving to remove microorganisms and free their bound nutrients. Cultivation conditions provided sufficient gas exchange by shaking and supplying CO_2. Algal growth was monitored by measuring OD (optical density) at 750 nm and correlating the results with measured dry weights of algae. The resulting correlation served as a calibration curve for assays of unknown algal growth potential. For the test samples of wastewater and surface water, optical density was monitored in the growth vessels until a maximum value was obtained, and the resulting plateau value was then correlated with the calibrated dry weights. Good results were obtained for the above test samples. Dilution tests were also run for these samples and linear results were obtained for absorbence vs. % dilution.

4. CRITIQUE OF SESSION

Poster No. P-7 presented results of sludge thermal conditioning prior to pressure filtration and incineration. The very favorable thermal balance depended on incineration as a final disposal technique, so that the heat produced during the incineration process could be used for the thermal pre-conditioning. Furthermore, total energy costs were not presented, so that the omission of dewatering costs required to obtain a cake dry enough for incineration could not be evaluated.

Poster No. P-11 correlated many operational clarifiers and sedimentation tanks within their sludge volume and surface overflow rate. No attempt was demonstrated to analyze the results. The algorithm developed could have been useful, but no output was presented. It was difficult to determine how the analogue family of curv related to the digital operation of the computer algorithm. Were there three subprograms in the algorithm, one to operate on each characteristic curve? How did the resulting storage capacity parameter relate to the usual surface area design parameter?

Poster No. P-14 demonstrated a useful technique for evaluation of water for the production of algal biomass. It was quantitative and standardized so that universal use could result in an "algal productivity index." The procedure would be particularly useful as a diagnostic tool to determine the need for further wastewater treatment prior to discharge or to determine the capability for protein production as a food source.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The three posters evaluated (Poster Nos. P-7, P-11, P-14) did not seem to have much application to U.S.A. water pollution problems. Only Poster No. P-14 could be used or adopted as a "standard procedure" for the evaluation of algal growth potential.

1. SESSION

A. Days: September 17-21, 1984
Location: RAI Conference Center
Amsterdam, The Netherlands

B. Theme of Poster Presentations: Control of Wastewaters and Treatment Works

2. REVIEWER

A. Name: Herbert C. Preul

B. Position and Affiliation: Professor of Civil and Environmental Engineering, University of Cincinnati, Cincinnati, Ohio (U.S.A.)

3. DESCRIPTION OF POSTER PRESENTATIONS

A. Poster No. P-4: "A Low Cost Portable Water Testing Kit for Developing Countries" by D. Wheeler, M. Snook, B. Lloyd (United Kingdom)

One of the principle objectives of the UN International Drinking Water Supply and Sanitation Decade is to provide safe water for all. The success of the Decade in this respect may only be judged by the application of routine monitoring and surveillance schemes to assess the microbiological, physical and chemical quality of water supplies. Furthermore, it is arguable that only the early inception of such programs will ensure the selection of appropriate water treatment and supply schemes capable of raising public health standards by improving the hygienic quality of water. Unfortunately, routine water quality testing has not been undertaken in the great majority of developing countries to date for the following reasons: water quality is generally poor and obviously contaminated; there are few qualified technicians competent to execute testing; there has been no infrastructure to organize routine surveillance programs; and, the methodology of monitoring has been too sophisticated and expensive.

Many initiatives designed to reduce the problems of persistent contamination of drinking water supplies have been undertaken in developing countries. A large proportion of such intervention programs were launched before the advent of the Water Decade, and there have been major difficulties in defining the positive impact of improvements in water quality. But, with increasing recognition of the importance of hygienic water supplies, national governments around the world are now developing the essential infrastructures and training programs for water quality monitoring as part of their Decade efforts. However, a fundamental problem--the absence of really appropriate analytical equipment--remains and has been highlighted with particular reference to field testing in developing countries in this poster.

The majority of parameters listed by international (WHO), European Community (EC) and U.S.A. water quality standards are chemical characteristics which vary little over protracted periods of months or even years. Although all parameters should be examined when planning new water supply projects, it is generally impractical and uneconomical for most provincial water supply agencies or health authorities to consider anything other than the most essential tests for routine application. Thus, the following series of tests are considered to be the most relevant for the regular assessment of rural water supplies: fecal coliform density--the most reliable and universally accepted index of hygienic quality; turbidity combined with filterability--the simplest means of assessing; (a) treatment process requirements, and (b) the physical performance of treatment installations; chlorine residual--obviously essential when disinfection is practiced; conductivity--a valuable substitute for chloride analysis in permitting the early detection of sewage or saline intrusion; and, pH--essential where chemical treatments such as coagulation or disinfection are practiced.

With support from OXFAM, the above listed tests have been packaged into a single portable container. Together with the normal subjective tests of odor, taste and color, and a visual inspection, they form the basis of a standard water testing protocol. The authors have field tested the kit for a period of twelve months in Peru. In addition, it is now in routine use in other developing countries.

One of the major criticisms of conventional water analysis is that the information produced is retrospective due to the need for sample transfer to the laboratory. In remote rural areas, difficulties in transport and communications often render centralized analysis costly and inefficient. Conversely, the advantages of on-site analysis, particularly with respect to developing countries are: corrective action can be initiated without unnecessary delay; the role of the water quality office/sanitary inspector is reinforced; and, the need for sample preservation and transport is obviated. Thus, it is believed that the portable testing kits, as described in this Poster, will prove to be useful tools in the raising of public health standards in the rural sector of developing countries.

B. Poster No. P-10: "Upgrading of Existing Treatment Works" by T. Muller, J. Janus (The Netherlands)

This work was commissioned by the Veluwe Water Authority of the Netherlands and was carried out for the purpose of processing sludge into a useful product under conditions when the agricultural use of sewage sludge is not possible.

Requirements for end product properties included: approximately 40% dry solids content; and consistency appropriate for dumping. Sludge dewatering alternatives included: use of sieve belt-presses in combination with mixing with sand, lime or sand and lime; and use of membrane filter presses. Dewatering with sieve belt-presses using sand and lime addition was selected for the following reasons: yearly cost; flexibility; energy consumption; and quality of final product. Conclusions of an optimization study indicated the optimum mixing ratio for sand and lime was 90/10 (mass basis); hydrated lime was not suitable; premixing of sand and lime was not necessary; and the end product was suitable for use in cover and for interlayers of waste disposal sites.

C. Poster No. P-20: "The Lagoon of Santa Gilla (Sardinia): Present Conditions and Possibilities of Restoration" by A. Contu, P. Mulas, G. Sarritzu, M. Schintu, N. Sechi, and A. Ulzega (Italy)

The lagoon of Santa Gilla of about 1500 ha, corresponds to the terminal western part of the Campidano Plain and is placed between the reliefs of granite and schist of the Sulchis to the west and the Arenacecus marl-limestone hills of Cagliari, Italy to the east. Its environmental situation was changed profoundly during the last thirty years, beginning in the 1960's when modest bacterial pollution was verified. In early years, the lagoon was abounding in high quality fish, but because of domestic sewage from the Town of Cagliari and the industrial wastes from petro-chemical industries, pollution has increased to the point that fishing had to be completely prohibited in 1984. The aim of the Poster was to verify the present situation in light of the recent reclamation works and to evaluate the possibility of restoring the lagoon to its original natural conditions.

Analytical results presented in the form of charts included: total coliform; fecal coliform; fecal streptococci; lead; copper; mercury; total phosphorus; ammonia; nitrogen; and eutrophic and morphological observations.

Although certain restoration works have considerably improved the situation of the lagoon, especially from the bacteriological point of view, the levels of lead, mercury, and copper in the sediments are still so high as to hinder and nullify the treatment methods proposed to recover the lagoon for fishing. In any case, it is imperative to stop the input of all pollutants. The vertical profile of sediments shows very high concentrations of heavy metals at a depth of 40 cm. Dredging operations, therefore, involve both immense expenses and unforeseen consequences on the ecosystem and may reduce only partly the level of heavy metals in the sediments. The possibility of favoring the natural removal of superficial sediments by better streams with an appropriate control of the waters through the mouths of the lagoon could also be taken into account. A gradual diversion of the pollutants from the lagoon to the Gulf of Cagliari has been pointed out in a previous work and is corroborated by a slight decrease in the levels of heavy metals recorded since 1977 in connection with a lower input of wastes. To speed up this self-purification process may have an adverse effect on the marine ecosystem and may extend the problem to the Gulf of Cagliari.

4. CRITIQUE OF SESSION

The poster presentations concentrated on methods of controlling wastewaters and evaluating their effects. New techniques and approaches were emphasized.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The reported results in the posters are seen as being pertinent to U.S.A. needs in the form of approaches for controlling and monitoring water quality.

The low cost portable water testing kit, described by Poster No. P-4 and available through OXFAM in England, is indicated to be a useful step forward for field testing purposes and should have application for many rural situations in the U.S.A.

The results on the handling of sludge, as reported in Poster No. P-10, certainly outline important new possibilities for applications in the U.S.A.

The experience in the gross pollution of a very large lagoon in Sardinia, Italy, as reported in Poster No. P-20, is an extremely important lesson in the allowance of uncontrolled sewage and industrial wastewaters. The approaches for recovery of the lagoon quality bear a reference for possible related cases in the U.S.A.

1. SESSION

   A. Days: September 17-20, 1984
      Location: RAI Conference Center
      Amsterdam, The Netherlands

   B. Theme of Poster Presentations: Wastewater and Sludge Treatment Processes

2. REVIEWER

   A. Name: C. P. Huang

   B. Position and Affiliation: Professor, Department of Civil Engineering, University of Delaware, Newark, Delaware (U.S.A.)

3. DESCRIPTION OF POSTER PRESENTATIONS

   A. Poster No. P-49: "Recent Studies of Systems for Small-Scale Wastewater Treatment in The Netherlands" by J. van der Graaf and H. Webers (The Netherlands)

A total of 12 small wastewater treatment systems with capacities ranging from five to 200 population equivalents have been studied and compared for their costs, operational reliability, environmental impact, operation and maintenance. These 12 systems were: septic tank-sand filter; septic tank-infiltration bed; septic tank-elevated mound; septic tank-trickling filter; septic tank-RBC's; activated sludge; presedimentation pond-RBC's-effluent pond; presedimentation pond-trickling filter-effluent pond; pond system; compost toilet-septic tank-sand filter; compost toilet-septic tank-infiltration bed; and, compost toilet-septic tank-elevated mound.

The results showed that there was little difference economically among the 12 systems with the activated sludge system the most expensive and the septic tank-infiltration bed system the relatively cheapest one. All systems were labor intensive, as expected for small-scale wastewater treatment systems. All factors considered, the septic tank-infiltration bed system scored the highest over all other systems.

After evaluating these 12 systems, a field study on the performance of 13 selected wastewater treatment systems has been conducted. Grab samples (both influent and effluent) were taken for physical and chemical analyses including BOD, COD, TJN, NH_4^+-N, NO_3^--N, PO_4^{3-}-P, SS (TSS and TVSS), O_2, pH, temperature and flow rate. The field test has yet to be completed.

B. Poster No. P-5: "Investigations on the Anaerobic-Aerobic Treatment of a High Concentrated Wastewater" by A. Mennerich (Federal Republic of Germany)

A two-stage treatment scheme consisting of an anaerobic column (upflow type) followed by an aeration reactor has been used to treat leachate from a sanitary landfill in Hanover. The research project has covered laboratory-scale experiments and four pilot-scale reactors of 12 m^3 volume each. However, only laboratory results have been presented. The two-stage treatment concept aimed at an 80% COD-removal in the anaerobic step and the elimination of the residual COD and nitrification-denitrification in the aerobic step.

Four modes of anaerobic reactors have been tested: (1) anaerobic filters, operated under upflow and at 30°C. The filters are packed with various support materials, i.e., composted municipal solid waste (MSW), stones, plastic media, burned clay; (2) anaerobic filters operated under upflow and at ambient temperature. MSW, lava slag, and burned clay are used as support materials; (3) anaerobic filter operated under downflow and at different temperature, i.e., 30°C vs. ambient. Composted MSW is the sole support material; (4) upflow reactor.

The anaerobic reactors were 1.6 m high with a total volume of 70 L. Generally, the anaerobic filters containing MSW materials performed slightly better than other inert materials; reactors operated at 30°C also yielded better results than at ambient temperature (18-27°C).

Forty days after start-up of a reactor, for example, effluent TOC remained constant at 2,000 mg/L (vs. an influent TOC of 19,000 mg/L) independent of loading rate. The pH values also remain constant at 8-8.3, and a methane content of 72-77% (by volume) was observed in the product gas. Most of the TOC removal occurred in the lower 25% (40 cm) of the reactor. The sludge concentration was also the highest in the lower part of the anaerobic reactors, present not as attached biomass, but as sludge filling in the void spaces of the support media. The low pH of the influent has no adverse effects on the methanogenic activity.

The results have shown that after an abrupt increase in COD loading, gas production rises immediately. A temporary shutdown and the restart of the anaerobic filters caused no problem. Apparently, the anaerobic filters were able to sustain temperature fluctuation. Difficulties arise from inorganics such as iron (700 mg/L) and Ca (1900 mg/L) which form precipitates at the pH value in the filters. Inorganic precipitates tended to clog the anaerobic column. Preliminary results on the treatment of anaerobic effluent by the activated sludge process have shown poor nitrate removal.

The pilot plant under construction is a 2-m diameter concrete well of 4.5-m height, located in the slope of the landfill body and enclosed from the refuse. The pilot plant includes the following reactor types: anaerobic MSW filter; upflow activated sludge blanket reactor; anaerobic filter (burned clay); and, anaerobic filter (plastic media).

C. Poster No. P-44: "Mass Transfer Mechanisms in a Heterotrophic Biofilm" by H. Siegrist and W. Gujer (Switzerland)

The objectives of this study were to measure molecular diffusion in naturally grown biofilms, to determine the contribution of eddy diffusion and the influence of electrostatic force on the diffusion of charged chemical species, exemplified by Br^-, Na^+ and glucose.

The results have shown that in the absence of eddy diffusion, the average diffusion coefficient is constant over the biofilm depth. Above a certain biofilm thickness, eddy diffusion becomes important, thereby increasing the average diffusion coefficient. The mechanical structure of the biofilm matrix tends to reduce the molecular diffusion to 50-60% of that in pure water. Depending upon the roughness of the biofilm surface and the flow conditions, eddy diffusion may play a pertinent role in mass transfer. In their experiments, eddy diffusion was observed at a biofilm thickness of $> 100\ \mu m$. Mass transfer effects by electrostatic forces were not important at the ionic strength of wastewater and tap water studied (10^{-3} M).

A two-cell reactor, consisting of a large compartment (~1200 mL) and a small compartment (~76 mL) was used to study the mass transfer of these three chemicals. The biofilm was formed by growing biomass on a sartorius membrane filter which was mounted between the two chambers and rotated on a horizontal axis.

D. Poster No. P-35: "Dynamic Response of Final Clarifiers" by J. Dietz and T. Keinath (U.S.A.)

Laboratory-scale continuous flow clarifiers were used to study the dynamics of sludge settling. Calcium carbonate was selected as the model sludge particles, and experiments were conducted by measuring the effluent calcium concentration upon a sudden increase in overflow rate with a constant influent solids concentration. Feed-well depths of 1.7 m and 0.8 m and an overall total depth of 3.7 m were used. These depths corresponded to a retention time of 2.4 h and 1.2 h, respectively. The results showed that the effluent Ca concentration upon shock loading increased exponentially with time (or a first-order rate expression), with a rate constant of 2.3 h^{-1} and 4.7 h^{-1}, respectively, for the feed well depths of 1.7 m and 0.8 m. Steady-state condition was rapidly attained in both cases within two hours after forcing. The steady-state effluent solid concentrations were 5 and 6 mg/L. The quickness in response to dynamic loading was attributed to the concentration profile of the feeding particles which was speculated to be hypobolic.

The authors concluded that short-term perturbations in the overflow rate produce an immediate response and that a steady-state approximation model can be used with little sacrifice in accuracy due to the rapid dynamics. In spite of their findings, the authors have also cautioned against drastic flow rate variations and suggested specific measures for clarifier flow control.

E. Poster No. P-38: "Complete Reclamation of Wastewater and Sludge" by B. Elkins, G. Wilson and R. Gersberg (U.S.A.)

The purpose of this study was to develop an innovative wastewater (physical-chemical) treatment process with special emphasis on sludge utilization.

Raw wastewater, after coarse screening, was pretreated with a stacked screen/tea-cup degritter, where a clay slurry was also added. The mixture of screened wastewater and clay slurry dropped 0.6 m into the tea cup degritter where sand and other grit larger than 50 m is removed. The sand and grit from the tea cup was settled in a container with effluent returned to the raw wastewater stream. The degritted wastewater clay slurry mixture dropped 1.7 m into the sheet mixer and decayed-gradient flocculator where alum, polyacrylic acid and strong acid or base (for pH adjustment) were added. These chemicals were proportionately added as a thin film to the wastewater clay slurry mixture. Heavy flocs from the flocculator settle rapidly in a clarifier. Sludge is treated in a gravity thickener and is dewatered in a capillary pressure belt system. Dewatered sludge has a solids content of 45% and is conveyed to a pugmill mixer where it is mixed with coarse screenings and dry clay (i.e., montmorillonite) to produce a mixture having a moisture of 20-23% which is then extruded and pelleted. The pellets are heated in a rotating kiln to produce a lightweight aggregate containing microscopic air cells.

Wastewater treatment efficiency was also evaluated. The removal percentages for turbidity, SS, BOD, orthophosphate and total phosphate were 89%, 91%, 88%, 97% and 95%, respectively. However, the nitrogen removal efficiency was relatively poor.

4. CRITIQUE OF SESSION

Poster No. P-49 presents practical solutions to some wastewater problems for the small community. The effort of the entire research project is great. However, the significance of the outcome is not proportional to its effort. It is almost expected with a high degree of certainty that wastewater or water treatment facilities for small communities are labor intensive.

Poster No. P-5 was a practice-oriented presentation. The results obtained from laboratory-scale experiments were interesting. The use of municipal solid waste materials as a support for an anaerobic column reactor was innovative. However, it must be noted that pretreatment for iron, calcium, and manganese removal was essential to warrant successful operation of the anaerobic reactor. Moreover, information on the COD removal efficiency of the aerobic activated sludge process was sketchy; a fair assessment of this total process is still not possible.

The important aspect of Poster No. P-44 was the uniqueness of its experimental design--the use of a two-cell reactor with a rotating biofilm as membrane in between them. Although the reported results were limited to bromide ion (Br^-), sodium ion (Na^+) and glucose, it is expected that the authors have studied other specific chemical species but not reported in the poster presentation.

The performance of the clarifier has been the constant attention of many researchers and practitioners. The conclusions of Poster No. P-35 would be more convincing had the authors also measured the solids concentration profiles in the clarifier. These data will assist the interpretation of the rapid response of the clarifier upon a forcing overflow rate. Moreover, there is reservation about the use of calcium carbonate in lieu of sludge particles. The physical and chemical properties of calcium carbonate particles are different from those of municipal-sewage particulates. Finally, no explanation has been offered on the difference in effluent solid concentration at steady-state of the two experiments conducted.

Poster No. P-38 was a very useful work, especially the production of lightweight aggregate from sludge. The low removal efficiency for organic nitrogen and inorganic nitrogen by the process was expected, especially since nitrate ion is not usually adsorbable on solids.

Several omissions have been noted in the presentation including: the pH value in the sheet-mixer-decayed-gradient flocculator; velocity gradients, in the decayed-gradient flocculator; the range of temperature used in the kiln; and criteria for the selection of clay, alum and polyacrylic acid dosages. Finally, an economic comparison between the CCBA process and one with conventional activated sludge process followed by the sludge fixation step used in this CCBA process is needed. Can the sludge fixation process be operated at favorable economic scale using regular or any municipal sludge?

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The significance of the posters presented in this session varies. Treatment of high-strength wastewaters, such as sanitary leachate and industrial wastes, remains a presently urgent task to U.S.A. pollution control workers. The ultimate disposal and utilization of municipal and industrial sludges is definitely another important area yet to be tackled. Further research is greatly needed in the areas of solid-liquid separation and treatment of concentrated high-strength wastewaters.

1. SESSION

   A. Days: September 17-20, 1984
      Location: RAI Conference Center
      Amsterdam, The Netherlands

   B. Theme of Poster Presentations: Water Treatment

2. REVIEWER

   A. Name: Charles P. Gerba

   B. Position and Affiliation: Associate Professor of Microbiology and Nutrition and Food Science, University of Arizona, Tucson, Arizona (U.S.A.)

3. DESCRIPTION OF POSTER PRESENTATIONS

Poster No. P-25: "Remineralization and Potabilization of Desalinated Water" by Y. Henderyckx (Belgium)

This poster described the treatment of water produced by distillation of seawater so that it would meet potability standards set by the World Health Organization. The facility is located in Dubai with a daily output of 26,208 m^3/d. Water produced by the process is not buffered and is low in dissolved solids. To prevent corrosion and meet drinking water standards, carbon dioxide is injected into the water to be treated before it passes through a remineralization material consisting of calcium carbonate. In addition, a small amount of seawater (0.8% to 0.9%) which has been chlorinated and filtered is added to have the required contents of chlorides, sulfates and bicarbonates.

The author stated that additional studies are now being carried out with the purpose of making such a treatment process and methods accessible to distillation installations that do not produce enough carbon dioxide and also to bring into general use the application of these processes for the treatment of naturally low mineralized waters and for neutralization of acid waters.

1. SESSION

   A. Days: September 17-20, 1984
   Location: RAI Conference Center
   Amsterdam, The Netherlands

   B. Theme of Poster Presentations: Modular Water Treatment of Hazardous Wastes and Prediction of Lake Water Quality

2. REVIEWER

   A. Name: Francis A. DiGiano

   B. Position and Affiliation: Professor of Water Resources Engineering, University of North Carolina, Chapel Hill, North Carolina (U.S.A.)

3. DESCRIPTION OF POSTER PRESENTATIONS

   A. Poster No. P-3: "A Modular Water Treatment Package for Surface Waters in Rural Locations of Developing Countries Incorporating Novel Design and Operational Features" by D. Wheeler, M. Pardon and B. Lloyd (United Kingdom)

This poster described a commercially available product (Potopak Water Purification System) which had originally been developed at the University of Surrey (United Kingdom). Unfortunately, supporting data and mechanistic explanation for the process were lacking. The innovative feature of the system is a synthetic fabric mat enclosed in two removable cartridges located above a 50-cm bed depth of sand; the filter module is otherwise described as a gravity flow, slow sand filter. Each module is intended to serve 250 persons in the developing world. The synthetic filter mat is removed from the filter (perhaps only the upper cartridge must be removed, although this is unclear) at approximately monthly intervals for cleaning under running water while the sand bed itself is backwashed in the usual manner. The hydraulic features of the filter module were not explained clearly. A constant flow is to be obtained by allowing the head to build up above the filter to compensate for head-loss accumulation.

The cartridges are purported to extend the filter run time by removing silt and organic matter; they also promote attached growth of microorganisms that improve water quality. The idea is that if only the upper cartridge is removed for cleaning, the attached growth in the lower cartridge remains undisturbed. The unit is being field tested in Peru.

It is not clear if a conventional slow sand filter would provide the same degree of treatment. Although the product literature emphasizes these filter modules to be easily maintained, they nonetheless require attention to the rate of head-loss accumulation. No field data are provided to support the claim that the cartridges only need monthly cleaning.

B. Poster No. P-12: "Groundwater Pollution Resulting from the Disposal of Wastes in the 'Volgermeer polder' Situated North of Amsterdam" by J. van der Schroeff (The Netherlands)

The consulting firm of Grontmij (The Netherlands) was responsible for preparing this poster. A solid waste site was described in which leaching occurred into the groundwater through a sandy soil layer of a polder, a dry land area in the Netherlands created artificially by pumping. The dump site contained organic chlorine compounds. To prevent further contamination of the groundwater, the consulting firm recommended lowering the groundwater level by 3 m. Technical details were not included. The poster focused on methods of treating the leachate which will still be generated due to the high level of freatic water in the polders. Two treatment schemes were pilot tested: (1) air flotation, rotating biological contactors, filtration, and carbon adsorption, and (2) three-stage reverse osmosis. On the basis of the specific and surrogate parameters chosen for evaluation, the reverse osmosis system gave better removals. However, it is about 14% more expensive, produces a concentrate to be discharged into surface water and must be kept anaerobic to prevent fouling by metal oxides. The biological system did not meet all of the effluent standards. It was also subject to fouling by metal oxides and foam and produced sludges and waste activated carbon. The poster did not explain if either treatment scheme had been decided upon, and details of the pilot-plant operation were not included.

C. *Poster No. P-17*: "Predictions of Micropollutants in the Future Freshwater Basin Volkerakmeer/Zoommeer, The Netherlands" by E. van de Vrie, G. van Eck and N. M. de Rooij (The Netherlands)

The Volkerakmeer/Zoommeer is a planned fresh water basin which will receive flow from the Rhine and Meuse. Because both of these rivers contain significant sources of contamination, it was necessary to develop a mathematical model of the artificial lake system in order to predict water quality. The model chosen was based on the work of DiToro, *et al*. ("Modeling the Fate of Chemicals in the Aquatic Environment," *Ann Arbor Science Publications*, 1982). The lake was divided into three completely mixed reactors in series in which the following processes were considered: partitioning between particulate and dissolved species in the water column; sedimentation of particulates; diffusion/exchange from the sediments; and partitioning between particulate and dissolved species in the sediments.

Use of the model required that three constants (two partitioning constants and one diffusion constant) be determined by calibration. Because the lake is not yet built, there were no data available for calibration. Therefore, data from an existing system that receives flow from the Rhine and Meuse rivers was used instead. The parameter selected for calibration was zinc, although no rationalization was provided for its selection. Reasonable calibration was obtained for eight years of data. The observed and calculated water column concentration decreased; the sediment concentration generally increased, although the trend of the observed data was not that clear. On the strength of these limited results, the model was used to generate a prediction of zinc concentration for the new lake system for an unusually long time (200 years). The simulations showed that zinc will build up both in the water column and in the sediments. If the simulation time was to have been limited to a more reasonable period of 20 years, very little increase would have been predicted. No further explanation was given for the selection of 200 years. The conclusion reached was that the model was capable of simulating concentrations of micropollutants in the water and sediments. This conclusion is inappropriate given the limited verification provided.

4. CRITIQUE OF SESSION

Poster No. 3 (United Kingdom) was essentially a commercial advertisement for a new product and did not provide enough supportive data on practical operation nor on the theory of the synthetic filter mat that made the system unique. Poster No. 12 (The Netherlands) did not present new technology, but rather an engineering evaluation of existing treatment processes. The treatment of hazardous wastes is an important topic, but this poster gave no new insights. Poster No. 17 (The Netherlands) relied upon existing water quality modeling concepts and provided no new information. The modeling approach would have been acceptable if a more convincing calibration and a shorter simulation period had been presented.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The significance of these three poster sessions is very limited. None gave a direction to future research that would aid activities in the U.S.A. This is not to say, for example, that the problem of providing safe drinking water to developing countries (Poster No. 3) is unimportant; rather, the approach presented to solve this problem lacked substance.

1. SESSION

A. Days: September 17-20, 1984
Location: RAI Conference Centre
Amsterdam, The Netherlands

B. Theme of Poster
Presentations: Acidified Waters

2. REVIEWER

A. Name: Edwin E. Herricks

B. Position and
Affiliation: Associate Professor of Environmental Biology, University of Illinois, Urbana, Illinois (U.S.A.)

3. DESCRIPTION OF POSTER PRESENTATIONS

A. Poster No. P-39: "Environmental Acidification and its Consequences for Toxicity of Weak Acids and Bases to Aquatic Organisms" by I. van der Putte and M. A. Brinkhorst (The Netherlands)

This poster reviewed a series of toxicity tests on Daphnia and Rainbow trout designed to test the additive toxicity of weak acids or weak bases when an organism is exposed to multiple stresses. The authors found a good correlation between toxicity and pH, the relationship defined by the toxicant. For example, toxicity of nitrite to Daphnia decreased, while the toxicity of chromium increased pH. The authors also showed change in toxicity with weight for Rainbow trout, increased toxicity noted for smaller fish. The authors recommended that when toxicity is noted in waters which are subject to acidification, the effects of weak acids and bases should be considered to adequately identify the cause of toxic effects.

4. CRITIQUE OF SESSION

Poster P-39 developed a relationship for additive toxicity of protonated and deprotonated forms:

$$1/LC_{50} = T_m - (T_m - T_i)\ K_a/([H^+] + K_a)$$

where: $1/LC_{50}$ is an expression of total toxicity, T_m is the toxicity of the protonated form (HA), T_i is the toxicity of the ionized or deprotonated form (A^-) of a weak acid and K_a is the acidic-ionization constant. This relationship provides a basis for general evaluation of joint toxicity, an area of toxicity investigation which is extremely important in dealing with complex effluent toxicity. The poster also discussed data for Bluegill, but no toxicity data was presented.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

Poster No. P-39 provided data which was applicable to the evaluation of the consequences of acid rain and provides a defined relationship for additive toxicity evaluation which may be applicable to complex effluents.

1. SESSION

   A. Days: September 17-20, 1984
      Location: RAI Conference Centre
      Amsterdam, The Netherlands

   B. Theme of Poster Presentations: Water Quality and Heavy Metal Chemistry

2. REVIEWER

   A. Name: C. P. Huang

   B. Position and Affiliation: Department of Civil Engineering, University of Delaware, Newark, Delaware (U.S.A.)

3. DESCRIPTION OF POSTER PRESENTATIONS

   A. Poster No. P-16: "Prediction of Nutrients and Chlorophyll in Future Freshwater Basin Volkerakmeer/Zoommeer" by G. van Eck and N. M. de Rooij (The Netherlands)

The results presented in this poster represent only a fraction of a research project intended to assess the environmental impact of a water basin yet to be created in the southwest part of The Netherlands. In mathematical modeling, the water basin is divided into three completely mixed reactors, each containing the water and the sediment phaes. Rate expressions were established for each parameter of interest by taking into account various input and decay mechanisms. The model has been calibrated with a set of field data on zinc from another water body created since 1970. As pointed out by the author, more information is still needed to assess the influence on the model results of the following parameters: diffusion-exchange of materials at the water-sediment interface; thickness of the active sediment layer; various transport mechanisms for suspended matter, and distribution coefficients as affected by various environmental conditions.

B. Poster No. P-48: "Evaluation of Alternative Measures for Controlling Pollution in Part of West Morava River Basin" by A. Filip and D. Obradovic (Yugoslavia)

A mathematical model, STISKAR, has been developed to describe the ambient water quality in the West Morava watershed. The total length of the West Morava River and its tributaries, Despotovica, Dicina and Cemernica, is 94 km. Two major towns, Cacak and Gornji Milanovac, are located in this basin. The model evaluates the impact of wastewater loads, both municipal and industrial, from these point sources upon the water quality of the watershed. It was found that existing water quality criteria were not met in these rivers during low flow conditions even if a flow increase of 1.0 m^3/s to the West Morava was applied. Locations and the extent of BOD (carbonaceous) and dissolved oxygen criteria violations were determined for measured pollution loads.

Different alternatives of water quality protection were formulated and analyzed by the model. Each alternative was a set of different water treatment levels for all point sources. Wastewater dislocation was also considered in some cases. Using a step-by-step procedure, several alternatives have been formulated which lead to better ambient water quality criteria. An alternative that will meet water quality criteria throughout the basin was selected.

C. Poster No. P-55: "The Influence of Rainfall Characteristics on the Pollution Emission" by K. Bakker and H. S. J. van Wieringen (The Netherlands)

An extensive data collection program has been conducted through The Netherlands to provide data on quantities and qualities of stormwater discharges from sewer systems into surface water. This poster reports the results of the Loenen combined sewer system.

Run-off coefficients have been assessed and shown to be seasonally influential. In the winter time, the run-off coefficient related to impervious area was higher than 1.0. During the summer time, the run-off coefficient is less than 1.0. The emission of suspended solids depended on rainfall characteristics. The time of filling of the sewer system typifies these characteristics and governed the concentrations of the suspended solids at the beginning of an overflow. The same applied to BOD and COD. Longer time of filling resulted in much lower concentrations, as compared with shorter time of filling. The suspended solid concentration during an overflow can be predicted with a good degree of accuracy by taking into account two effects: the depletion (washout) of the pollutants and the discharge at the overflow weir. Specifically, the discharge, Q; dry weather period, DWP; overflow volume, V; filling time, T; and storage capacity of the sewer system, B; were governing parameters for suspended solid concentration, C:

$$C = 230\ T^{-2/3}(DWP)^{1/5}(e^{-V/B})^{1/T} + kQ^2$$

The following equations were deduced for COD and BOD:

$$C(COD) = 42\ T^{-1/5}(DWP)^{1/5}$$

and

$$C(BOD) = 230\ T^{-1/5}(DWP)^{1/5}$$

D. Poster No. P-57: "Lake Naarden Conservation Strategy Supply Water Treated in Special P-Removal Unit" by E. L. C. Koster, P. L. Wuite, and A. S. Hogendoorn-Roozemond (The Netherlands)

Due to a lowering of the polder water level in the west, an increasing groundwater withdrawal in the east and a decline in summer rainfall, the shallow Lake Naarden is facing a decrease in surface water level at an alarming rate. A feasibility study has been conducted to develop and evaluate several alternatives for additional water supply. Three possible water supply areas are considered: Ijmeer (southern part of Lake Ijasel), Speigelplas (deep lake in the Spiegel-en Blijkpolder) and Horstermeerpolder (seepage area of fresh and saline ground water). A set of evaluation matrices including aspects of short-term feasibility, minimum interference in the existing landscape features and possible conflicts with other interests, such as agriculture, is used to select the water supply area. Ijmeer is finally chosen as the water supply area.

In order to meet the water quality requirements, phosphate removal is necessary. A compact, low cost treatment facility is designed and installed at the inlet to Lake Naarden. Phosphate removal is carried out by flocculation with $FeCl_3$ and the sludge produced is retained in a lamella separator-sludge thickener combination. The sludge is subsequently dried in sludge lagoons.

E. Poster No. P-42: "Partial Extraction of Metals from Soil to Evaluate Pollution" by C. W. Randall, C. D. Donaldson, P. J. Wiginton, Jr., T. J. Grizzard and W. R. Knocke (U.S.A.)

This poster presentation reported the results of an investigation to extract surface adsorbed metal ions, namely, iron, aluminum, manganese, lead, and zinc, from soil particles at room temperature. It was also intended to preserve the silicate matrix structure during extraction. Three variables, the acid solvent type, the acid strength, and the contact time were evaluated. Two polluted soils, a clay loam and a sandy loam, were studied.

The results showed that nitric acid was not as effective as hydrochloric acid and that optimum extraction of adsorbed metals can be accomplished using more dilute concentrations and shorter digestion periods if hydrochloric acid is used. Strong acid solutions (0.5 to 4.0 N) can cause crystalline structural damage at digestion times of 24 h or less at room temperature. Nearly complete extraction of adsorbed heavy metals from soils can be made without causing crystalline structural damage. For the clay soil, the optimum extraction procedure was the use of 3.5 N HCl at a digestion period of 19.3 h. For the sandy soil, the optimum conditions are 1.4 N HCl and a digestion time of 0.5 h. Since the optimum procedure for the clay soil extracted only 10.5% more total metals than obtained with 1.4 N at 10.5 h, this procedure is recommended for both soil samples. Extraction procedures using heat and concentrated acids were too destructive. The adsorbed metals, most likely to originate from environmental pollution, were most completely and the most easily extracted from soils. Lead was most easily extracted from both soils. Adsorbed zinc and manganese were also easily extracted, but zinc was more tightly bound to the clay soil, whereas manganese was more tightly bound to the sandy soil. It has also been found that the amounts of lead extracted generally decreased after long digestion times, indicating the formation of insoluble precipitates during extraction.

4. CRITIQUE OF SESSION

Poster Nos. P-16 and P-48 both deal with mathematical modeling of water quality. The mathematical approach was straightforward but provided no new advances in modeling techniques.

Poster No. P-55 by Bakker and van Wieringen (The Netherlands) took an empirical approach to the problem of stormwater. While equations can be derived based on field data to predict the concentrations of suspended soil, COD and BOD, there is no indication as to how these equations apply to other localities.

Poster No. P-57 was a practical study and provided a good example on lake conservation, although the approach was very straightforward and predictable.

The poster by Randall, et al. (Poster No. P-42) gave a thorough discussion of the acid extraction of metals from contaminated soils. Apparently, Cl^- ions are better complex-formers than NO_3^- ions. The metal-chloro complexes are not adsorbable onto the soil surface. This may be the reason HCl is more effective than HNO_3. The classification of metals in soil into water soluble, exchangeable, complexed, chelated or adsorbed and mineral provides a useful starting point for the study of soil metal chemistry but needs further clarification and studies of cause.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

In the area of water quality modeling, U.S.A. pollution researchers appear well ahead of their counterparts in the world. As a matter of fact, the models used in the modeling of the Volkerakmeer/Zoommeer basin in The Netherlands (Poster No. P-16) and the Morava River basin (Poster No. P-48) were originally developed by U.S.A. researchers.

The Dutch work (Poster No. P-55) on the influence of rainfall characteristics may have some value to U.S.A. pollution research. A broader data base, including perhaps a larger geographical area, is still needed to qualify these empirical equations as universally applicable.

There is a great need to standardize the metal extraction procedure from contaminated soils, sludge and sediments. The work by Randall et al. in Poster No. P-42 definitely points to the right direction.

More work is needed in this important area, at least to investigate more acid types or other extraction agents and to redefine the state of the chemical state of heavy metal in solid-water interfaces.

1. SESSION

A. Days: September 17-20, 1984
Location: RAI Conference Centre
Amsterdam, The Netherlands

B. Theme of Poster Presentations: Toxicants in Water

2. REVIEWER

A. Name: Bruce E. Rittman

B. Position and Affiliation: Associate Professor of Environmental Engineering, University of Illinois, Urbana, Illinois (U.S.A.)

3. DESCRIPTION OF POSTER PRESENTATIONS

Poster No. P-33: "The Response of Aquatic Organisms to Mixtures of Toxicants" by E. Christensen, C. Chen and J. Kannall (U.S.A.)

This paper had two main themes. The first theme was a comparison of three mathematical functions--Weibull, Probit, and Logit--for describing the growth-rate inhibition of various toxicants to algae. Using two algal species and six toxicants, the authors showed 11 inhibition responses. In six cases of the 11, the Weibull model gave the best fit. The authors considered the result significant because only the Weibull model has a mechanistic interpretation.

The second theme concerned a method for determining overall inhibition when two or more toxicants are present. The method required two parameters of interaction: λ, a measure of similarity of active sites, and ρ, a measure of species diversity. In one experiment with simultaneous addition of Zn^{2+} and Ni^{2+}, the site of action showed very high overlap, e.g., $\lambda \cong 1.0$.

A method for predicting the inhibitory impacts of multiple toxicants would be of very great value for assessing water quality impacts. The methods presented shows promise, but their ultimate utility cannot be assured, because so little work has been performed with multiple toxicants. However, the procedures presented could provide a good framework for analyzing such results.

4. CRITIQUE OF SESSION

The impact of toxicants on aquatic systems is a very important topic. Poster No. P-33 presented a potentially useful technique for interpreting inhibition from multiple toxicants, although future work is needed.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The poster session on toxicants in water demonstrated that continued research on effects of multiple toxicants is necessary.

1. SESSION

A. Days: September 17-20, 1984
Location: RAI Conference Centre
Amsterdam, The Netherlands

B. Theme of Poster
Presentations: Water Quality Modeling

2. REVIEWER

A. Name: Edwin E. Herricks

B. Position and
Affiliation: Associate Professor of Environmental Biology, University of Illinois, Urbana, Illinois (U.S.A.)

3. DESCRIPTION OF POSTER PRESENTATIONS

Poster No. P-18: "Prediction of Chloride in the Future Freshwater Basin Volkerakmeer/Zoommeer, The Netherlands" by J. Bakker and N. M. de Rooij (The Netherlands)

Poster No. P-18 was one of three posters (also Poster Nos. P-16 and P-17) dealing with modeling of the soon to be completed Delta Plan in the Eastern Scheldt (S. W. Netherlands). This poster dealt with predictions of chloride in the basin which will be completed in 1987. The chloride model was based on advances of modeling contaminant concentration.

4. CRITIQUE OF SESSION

Poster No. P-18 provided an estimate of the chloride concentration as affected by flushing and pumping. Since the major water source for the basin is polluted and eutrophic water from the river Meuse, the analysis depended on a series of related models and analyses. Those models and analyses taken together constitute a useful predictive tool.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The modeling and prediction of the environmental effects of large water resource projects is an essential part of development activities in the U.S.A. Thus Poster Nos. P-16, P-17, and P-18 developed a comprehensive analysis of the expected characteristics of lakes developed in the Delta Plan. The models used and the approach taken can provide valuable insight for U.S.A. water resource development.

1. SESSION

   A. Days: September 17-20, 1984
      Location: RAI Conference Center
                Amsterdam, The Netherlands

   B. Theme of Poster
      Presentations: Water Quality Modeling

2. REVIEWER

   A. Name: David W. Hendricks

   B. Position and
      Affiliation: Professor of Civil Engineering, Colorado State University, Fort Collins, Colorado (U.S.A.)

3. DESCRIPTION OF POSTER PRESENTATIONS

   A. Poster No. P-2: "Surveying Tidal Fluxes of Metals through the Mersey Narrows, 1982 and 1983" by K. Whitelaw, J. Cole, P. Head and P. Jones (United Kingdom)

The poster presentation described the fluxes of eight trace metals, e.g., As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn, through the Mersey estuary in England. The flux measurements were based upon four 13-hour tidal cycle surveys for different tidal conditions. The objective of the measurements was a part of a long-term effort to ascertain the extent of metals pollution in the estuary. The work was a joint project of the Water Research Centre in Medmenham and the North West Water Authority.

   B. Poster No. P-22: "Optimization Modelling for the Selection of an Abatement Program for Diffuse Agricultural Pollutants" by J. Cousins and E. McBean (Canada)

The poster presentation described a small Canadian watershed in which an attempt was made to relate agricultural pollution, such as sediments, salts, metals, and BOD, to social concerns such as aquatic life, economic benefits of pollution control, costs to agriculture, and the social values related to options in pollution abatement. Because the goals were not definable mathematically, optimization as such was not feasible.

4. CRITIQUE OF SESSION

Poster No. P-2 demonstrated how great a field effort was needed to characterize a pollution flux of metals through an estuary. As papers on dispersion in estuaries have shown, the problem of flux measurement is complex because of tidal variations. To characterize such fluxes is difficult and requires strategic measurements at selected times. The authors have demonstrated how to handle such a problem.

Poster No. P-22 illustrated the manifold complexity of the problem. However, it did not show any quantitative data nor did it arrive at any conclusions.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The work of Whitelaw *et al*. (United Kingdom) in Poster No. P-2 illustrated the effort required in characterizing fluxes of water quality parameters. The work of Cousins and McBean (Canada) in Paper No. P-22 was not conclusive, and illustrated the nebulous character of the problem of dealing with agricultural pollutants. Neither of the posters had singular aspects which could be useful in U.S.A. water pollution research.

1. SESSION

   A. Days: September 17-20, 1984
   Location: RAI Conference Center
   Amsterdam, The Netherlands

   B. Theme of Poster
   Presentations: General

2. REVIEWER

   A. Name: Curtis W. Bryant, Jr.

   B. Position and
   Affiliation: Assistant Professor, Department of Civil Engineering, University of Arizona, Tucson, Arizona (U.S.A.)

3. DESCRIPTION OF POSTER PRESENTATIONS

   A. Poster No. P-9: "Chlorinated Phenols and Their Derivatives in Soil and Groundwater Around Wood-Preserving Facilities in Finland" by R. Valo, V. Kitunen, M. S. Salkinoja and S. Raisanen (Finland)

Results showed that different chlorophenol species were found at different soil depths, but all phenoxyphenols were found in the top five centimeters of soil.

   B. Poster No. P-40: "Modelling the Phosphate Concentration in a Shallow Lake, with Special Emphasis on the Effects of Sediment-Water Exchange" by P. Kelderman and A. Verwey (The Netherlands)

Laboratory experiments with intact sediment cores were carried out to investigate the effects of water temperature and surface water phosphate concentration on sediment-water exchange of phosphorus. Results were especially well summarized on a surface response chart that allows the phosphorus exchange rate to be read directly for any measured data pair of the study parameters.

4. CRITIQUE OF SESSION

Both presentations presented concise, usable results developed from strong data bases.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The problems addressed by the poster presentations are of equal concern within this country and readily usable results are presented in each.

1. SESSION

A. Days: September 17-20, 1984
Location: RAI Conference Center
Amsterdam, The Netherlands

B. Theme of Poster
Presentations: General

2. REVIEWER

A. Name: Paul T. Bowen

B. Position and
Affiliation: Assistant Professor, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, Oklahoma (U.S.A.)

3. DESCRIPTION OF POSTER PRESENTATIONS

A. Poster No. P-27: "Estimation of Mutagenic Activities and Physico-Chemical Indexes of Costal Sea Waters" by N. Kinae, M. Yamashita, T. Watanabe, M. Takahashi, S. Yamamoto and I. Tomita (Japan)

This study was undertaken to correlate the chemical indices DOC and TOC with mutagenic activity occurring in the coastal waters of Japan. Changes in mutagenic activity of these waters with the season were discussed.

Techniques for isolating mutagenic compounds were established by the authors. These methods, published in the proceedings of the 7th and 9th Symposium on Environmental Pollutants and Toxicology, are innovative and enabled the authors to isolate a large number of chemicals.

Sampling variations through the years prevented establishing a clear relationship between mutagenic activity and season. Ether extracts showed high mutagenic activity during the summer. Methanol extracts yielded lower mutagenicity values than other extracts for all seasons.

Pollutants extracted from sea water originated in industrial and domestic effluents. Of major interest was the lack of correlation between TOC or COD of the discharge and mutagenic activities. This lack of correlation was important in establishing the environmental impact of discharges on aquatic habitats.

B. Poster No. P-34: "Distribution of Suspended Particulate Matter Near Orange County, California Sewage Outfall" by R. Kolpack (U.S.A.)

The author used light transmission as a measure of solids concentration to profile the distribution of particles near the sewage outfall. He also studied the movement of these solids under varying ocean current patterns.

Results showed little or no accumulation of solids near the effluent. The solids were dispersed due to density gradients and strong subcurrents. The majority of the solids rise and migrate at a mid-depth point.

The mid-depth position of the solids in the water column makes them susceptible to movement by subcurrents. Currents tend to push the solids off shore, but as depth increases, the rate of movement decreases. Oscillating currents, which occur during tide changes or storms, were found to rapidly disperse the solids.

Almost half of the solids did not settle, but remained suspended in the water column. Of the solids which settled, 25% were transported between 300 and 2000 km before deposition.

If a system is properly designed and located, it is possible to effectively discharge solids without deposits. The distribution of these solids within the water column could pose problems as most remain suspended at mid-depth.

C. Poster No. P-37: "The Surfactant Profile of Municipal Wastewater: Influents and Effluents" by U. Zoller (Israel)

The absence of the author limited discussion of this topic. The poster indicated stated that cationic surfactants had decreased in the influent wastewater, but anionic and nonionic surfactants were increasing.

Evaluations of treatment effluents showed 95% anionic surfactant removal and 80% anionic surfactant removal.

4. CRITIQUE OF SESSION

The work presented on Poster No. P-37 was difficult to assess without the author's input. No problem statement was presented, and the work has limited value due to sufficient surfactant removal.

An attempt was made to correlate mutagenic activity with TOC and COD measurements of organics in sea water in Poster No. P-27. Although the value of this work is clear, the authors failed to adequately sample the sea water and statistically validate their results. These shortcomings lessen the credibility of their conclusions.

Poster No. P-34 described solids in the water column near an ocean outfall off California's coast. The work was well documented and valid. Only the use of light transmission is questioned, but the author's experience with this procedure and analytical correlations overcome these doubts.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

Developing a relationship between TOC or COD and mutagenic activity is important, yet the work presented is questionable. This area could use additional work and support. Solids dispersed in the water column near ocean outfalls concentrate at mid-depth. This work shows traditional design practices may need improvement. Additional support for work in this area is important.

CHAPTER III

PRE-CONFERENCE AND POST-CONFERENCE SESSION REPORTS

1. SESSION

A. Days: September 12-15, 1984
Location: Institute of Science and Technology
University of Wales
Cardiff, United Kingdom

B. Theme of Session: Seminar on Freshwater Biological Monitoring

2. REVIEWER

A. Name: Edwin E. Herricks

B. Position and Affiliation: Associate Professor of Environmental Biology, University of Illinois, Urbana, Illinois (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

The Seminar on Freshwater Biological Monitoring was organized as a pre-Conference activity held in association with the 12th IAWPRC Biennial International Conference. Conference presentations included 21 invited and contributed papers and 21 poster presentations. Sixteen of the conference papers were published in Advances in Water Pollution Control which was available at the conference (published papers are indicated by an * in the following summaries). The conference papers were organized into themes following a keynote address by Cairns (U.S.A.). The themes dealt with sampling, surveillance and monitoring approaches, and the integration of toxicity and mutagenicity testing in monitoring programs. A final paper dealt with regulatory issues and compliance biomonitoring. Poster presentations largely dealt with monitoring and surveillance results.

A. Paper No. 1*: "Freshwater Biological Monitoring: Keynote Address" by J. Cairns, Jr. (U.S.A.)

This paper reviewed the field of biological monitoring and placed both surveillance (a continued program of surveys systematically undertaken to provide a series of observations in time) and biological monitoring (surveillance undertaken to ensure that previously formulated standards are being met) in context with today's regulatory needs. The paper discussed predictive capability, selection of response parameters, the importance of biological monitoring, issues of thresholds, assimilative capacity, and effluent toxicity testing. A principle message of the presentation was the importance of biological monitoring in the hazard management process.

B. Paper No. 2*: "The Performance of an Invertebrate Colonization Sampler in Biological Surveillance of Lowland Rivers" by H. A. Hawkes and A. J. Watton (United Kingdom)

This paper, presented by Hawkes (United Kingdom), reviewed the use of artificial substrates and the evaluation of the data collected with the artificial substrates using a number of biotic indices. The studies identified reasonably good fits of biological condition with known water quality, but the three biotic indices used in the analyses did not show a strong correlation to ambient water quality. The authors stressed the importance of maintaining an abbreviated species-abundance list from sampling, reducing the reliance of biotic indices.

C. Paper No. 3: "Use of Artificial Substrates for Standardized Sampling of Macroinvertebrates in the Assessment of Water Quality by Means of the Belgian Biotic Index" by N. De Pauw, D. Roels, and P. Fontoura (Belgium)

This paper advocated the use of a standardized biomonitoring method based on artificial substrates. The method is being used in Algeria and Portugal where stream quality is now being mapped. The Belgian biotic index, as most European indices, is species oriented with a Saprobian system basis.

Because the majority of the conference attendees were from the United Kingdom, most discussion of biotic indices centered around the Biological Monitoring Working Party (BMWP) score and modifications. The Belgian biotic index provided another index used over an extensive area. Because the Belgian biotic index is based on standardized sampling procedures, it provides an opportunity for sampling with reduced variability allowing direct comparisons between sampling locations.

COMMENTS:

Paper Nos. 2 and 3 initiated a discussion of biotic indices which should be considered a major theme throughout the conference. A paper presented at the Amsterdam conference (Paper No. C-72) also provided a useful review of biotic indices commonly used in Europe. Since a great reliance is placed on various biotic indices in Europe, this topic can be found in most papers in the conference. Particular attention should be paid to the reviews of the Biological Monitoring Working Party (BMWP) score which has been developed in the United Kingdom. The competition between biotic indices is significant and the inappropriate use of these indices was identified as a major concern of the biologists present at this conference.

D. Paper No. 4*: "Biological Surveillance in Welsh Rivers for Water Quality and Conservation Assessment" by M. P. Brooker (United Kingdom)

This paper used the examples of macroinvertebrate surveillance data to present a general approach to biological monitoring data use which emphasized economy of effort and rapid decision making which could be coupled with resource conservation. The paper suggested the use of conservation as an objective where resources (both species and habitat) are protected. An emphasis in this paper was a call for development of an understanding of the relations between biological resources and habitat. The author suggested that fine tuning indices only leads to pseudo accuracy. A particular fault of many indices is the high degree of redundancy in the data produced. The major recommendation followed that if improved monitoring techniques, which eliminate redundance and extra costs, are adopted, funding would be available to conserve resources. In particular, this conservation would include the analysis of complex biological and ecological relationships.

E. Paper No. 5: "Classification of Running-Water Sites Using Macroinvertebrates and Recent Attempts to Predict Species from Environmental Data" by J. F. Wright (United Kingdom)

This paper summarized an extensive research effort conducted by the Freshwater Biological Association to examine the relationships between physical and chemical conditions and macroinvertebrate distribution in the United Kingdom. The paper is not available in the proceedings, but is available in extended form in a recent (1984) issue of the journal, Freshwater Biology (14:221-256 and 257-280).

From an evaluation of 370 sites on 61 river systems in the United Kingdom, a multiple discriminate analysis allowed separation of sites into groupings based on physical or chemical characteristics of the sampling site. The approach made good use of chemical data and provided an accuracy of 75% to 80% in predicting faunal characterists when water quality and physical characteristics were known.

F. Paper No. 6*: "Invertebrate Drift in the Biological Monitoring of Water Quality" by F. M. Chutter (South Africa)

This paper reviewed the test of abiotic index developed by the author in 1972 and advocates the use of drift sampling to simplify sampling and analysis. The study was designed to identify the alterations in drift along a stream gradient affected by treated sewage. The drift sampling utilized a quantitative paddle-wheel sampler during low-flow periods.

The reported relationships of changes in living and exuvial drift in relation to water quality alteration provides an additional tool in surveillance. Of particular importance was the finding that the composition of the drift does not seem to be affected significantly by long drift distances. The drift composition was characteristic of local benthic populations. Although the utility of using drift sampling was demonstrated in this study, the author cautions general application until the methodologies are applied in other river basins.

G. Paper No. 7*: "Early Warning of Eutrophication in Rivers by Analysis of Periphyton Chlorophyll a" by P. Heinonen (Finland)

This paper used chlorophyll a analysis as an indicator of eutrophication caused by the presence of fish farms on a high quality stream. The high nutrient loading (N and P) produced by the fish farm degraded water quality, reducing recreational value of the stream and eliminating natural trout reproduction.

The chlorophyll a analyses provided an early indication of watercourse degradation and is advocated as a valuable surveillance technique where nutrient addition, leading to eutrophication, is an identified problem.

H. Paper No. 8*: "Investigations into the Causes of Fishkills Occurring in the River Meuse (1979-1983)" by F. Van Hoof, W. Van Craenenbroeck, and D. Marivoet (Belgium)

This paper, presented by Van Hoof (Belgium), reviewed the use of fish tissue analysis as a means of identifying the cause of fish kills as well as a general monitor of fisheries condition using tissue metal concentrations.

The authors validated a fish kill source detection method based on analysis of fish pathology and tissue concentrations of expected pollutants. The continued surveillance of tissue metals concentrations showed changes in tissue concentrations and confirmed the use of gill tissue metal concentrations for chronic metal exposure monitoring.

I. Paper No. 9: "Assessing the Recovery of Two Coalfield Rivers: The Relationship Between Biology and Water Quality" by R. W. Edwards (United Kingdom)

This paper described the changes in water quality and biological conditions in two rivers, the Ebbw which flows to the Severn estuary through Newport, and the river Taff which flows to the Severn through Cardiff. Both rivers have been subject to long-term degradation. For example, coal has been produced in Wales since the 18th century (Taff), and an integrated steel works (Ebbw) has operated with production since the beginning of the 19th century. The major changes in the rivers were associated with the termination or modification of activities in the watershed rather than specific water quality management programs. In general, biological conditions improved with the removal of major stress on the receiving streams. Details of the recovery of the Ebbw and Taff were presented in posters presented at the conference.

COMMENTS:

Paper Nos. 3 through 9 as a group review surveillance and biomonitoring techniques. In this group, Paper No. 4 stands out because it dealt with conservation issues, in particular, that data needs must be clearly defined and collection should be limited only to what is needed. Paper No. 5 is one of the best reviews of stream classification available. The paper has correlated water quality and habitat conditions with species presence and abundance. Although the methods of habitat quantification may be weak, the work (cited in the summary for Paper No. 5) represents a comprehensive interim report on ongoing efforts in the United Kingdom in this area. The remainder of the papers in this group identify specific biomonitoring techniques and their utility in water resources management.

J. Paper No. 10*: "Aspects of Utilizing Continuous Automatic Fish Biomonitoring Systems for Industrial Effluent Control" by W. S. G. Morgan and P. C. Kuhn (South Africa)

This paper, presented by Morgan (South Africa), described an automated monitoring system which measured respiration (monitoring electrical signals generated by opercular muscle contraction) and activity (swimming rate monitored by ultrasonic techniques) in fish exposed to toxicants. The authors demonstrated a high degree of sensitivity for the monitoring system, although the system was not able to specifically identify the toxicant inducing a measured response. The test systems could maintain fish for long time periods and allowed development of detailed records of respiratory and behavioral patterns in test fish. The authors suggested that in industrial applications, individual fish may lose sensitivity to acute levels of toxicant and should not be retained for more than three months in the monitoring device.

This technique for rapid monitoring has been under development in a number of countries including the United States for approximately 15 years. A major application of the technique is found in South Africa where water resources problems are significant.

K. Paper No. 11*: "Automated Multispecies Biomonitoring Employing Fish and Aquatic Invertebrates of Various Trophic Levels" by E. L. Morgan, R. C. Young and C. M. Crane (U.S.A.)

This paper, presented by Morgan (U.S.A.), identified a number of modifications of continuous measurement biomonitors. Using a variety of holding chambers and sensitive micro-probe antennae to monitor bioelectric signals from fish, mussels, and aquatic insects, the authors demonstrated the utility of continuous monitoring in both laboratory and field applications. A system was described which allowed continuous monitoring of remote watersheds utilizing satellite relay systems.

The demonstration of the utility of continuous biomonitoring systems and the use of these systems in a variety of field and laboratory situations shows promise for advancing biomonitoring. The techniques discussed in Papers 10 and 11 have been available for a number of years, yet have found only limited applications. This paper has identified the development of sensitive micro-probes and the integration of biomonitoring with advances in communication and computerization.

L. Paper No. 12*: "Toxicity Testing with Freshwater Macroinvertebrates. Methods and Applications in Environmental Management" by K. Williams, D. Green, and D. Pascoe (United Kingdom)

This paper, presented by Williams (United Kingdom), reviewed the success achieved in using a number of freshwater macroinvertebrate species in toxicity testing. The authors advocated combining ecological and toxicological techniques to improve toxicity testing data, particularly interlaboratory comparisons. The authors suggested that a species selection approach should be developed which accounts for life history of organisms and provides for a greater variety of testing approaches. A major message of the paper was to make toxicity testing more ecologically oriented.

This paper provides a number of useful suggestions for the development of comprehensive monitoring programs which include toxicity testing and stream assessment activities. The procedures advocated are directly related to developing site specific criteria development and water quality based toxics control programs presently receiving major attention in the U.S.A.

M. Paper No. 13*: "Prediction of the Toxicity of Copper to Australian Freshwater Animals" by J. F. Skidmore and I. C. Firth (Australia)

This presentation by Skidmore (Australia) advocated using well designed toxicity testing programs with indigenous organisms to provide data which can be used to predict the effects of pollutant release. The authors have completed a series of toxicity tests using six fish, three mollusc and three crustacean species using taxa common to New South Wales, including a common northern hemisphere species to provide connection to world literature. The authors found a range of sensitivity to copper in their testing both between species and between life stages for one species.

The authors stress the importance of relating laboratory testing results to field situations. The work reported represents the initiation of a comprehensive program to evaluate toxicity in relation to potential ecological effects.

N. Paper No. 14: "Fate and Effects of Chemicals in Outdoor Ponds Compared with Predictions Based on Laboratory Tests" by N. O. Crossland (United Kingdom)

The author reviewed a series of experiments utilizing an outdoor pond test system to evaluate predictions made about the effects of toxicants from laboratory tests. A number of chemicals, including pesticides and industrial chemicals, have been subjected to detailed laboratory and field evaluations. Laboratory predictions in a number of field trials were observed, but predictions based on laboratory studies were not always confirmed in the field trials. The outdoor pond testing did provide replicate trials with realism.

This paper provided a review of a comprehensive experimental program to relate laboratory and field results. Although field experiments were carried out in artificial ponds, the procedures allowed the development of ecosystem complexity and provided a sound base for careful examination of laboratory predictions. Paper Nos. 12, 13, and 14 constitute a set of approaches to integration of field and laboratory studies to deal more effectively with ecological issues in toxicity testing.

O. Paper No. 15*: "Comparison of Biomonitoring Techniques for Evaluating Effects of Jet Fuel on Bluegill Sunfish (*Lepomis macrochirus*) by T. R. Doane, J. Cairns, Jr., and A. L. Buikema (U.S.A.)

This paper, presented by Doane (U.S.A.), reviewed a comprehensive testing program designed to evaluate the effects of jet fuel on the Bluegill sunfish. The experiments included acute and sublethal exposures and analyses spanned a range of physiological responses in addition to respiratory and behavioral (preference-avoidance) measures. The authors found that ventilatory rate was the most sensitive indicator of sublethal effect. A review of physiological and blood parameters measured identified few significant changes which were attributed to exposure to the toxicant. The authors noted that blood parameter analysis were not an effective means for determining sublethal effects.

This paper identified the value of comprehensive testing, but also revealed that completing a battery of analyses may not necessarily identify cause and effect relationships. Selection of biomonitoring parameters is not a trivial exercise, particularly when the intent is to discover the mechanisms of a noted organismic response. The comprehensive analyses reported in this paper provide an example of the value of comprehensive analyses, but also demonstrated that parameters measured may show no response to toxicant exposure.

COMMENTS:

Paper Nos. 10 through 15 and Paper No. 17 provide a review of the range of experimental approaches which can contribute to the value of biological monitoring. Paper Nos. 10 and 11 dealt with the use of techniques which monitor bioelectric signals from aquatic organisms. The application of this technology, both in industrial situations and at remote field sites, was reviewed. A number of specific toxicity testing results were presented, spanning the range from aquatic plants through invertebrates to fish. Paper No. 14 dealt with field experimentation as a method to confirm laboratory results. In general, this group of papers represented a reasonable sample of research activity in biomonitoring. These papers may contribute to ongoing USEPA analysis of site specific criteria and standards or permit land development.

P. Paper No. 16: "Intraspecific Variability to Stress Tolerance: Implications for Toxicity Testing" by P. Calow (United Kingdom)

This paper asked the question, what is monitored? The author stressed that the capacity for adaption and inter- and intraspecific variability can complicate the analysis of biomonitoring results. Using flatworms and leeches as an example, the author reviewed a number of studies which assessed differential sensitivity to toxicants and different levels of stress tolerance in organisms exposed to low levels of toxicant over a long time period. The author suggested that the selection of stress tolerant organisms at a polluted site may lead to adaptions which will allow maintenance of biological function and force recognition that physiological and organism presence or abundance measures may vary between sites and through time for the same species.

COMMENTS:

Paper No. 16 along with Paper Nos. 4 and 21 stand alone based on either topical coverage or approach. It is unfortunate that Paper 16 is not in the proceedings; it dealt with the issue of adaption and its consequences to biomonitoring. Although the importance of acclimation is widely recognized in biomonitoring, this paper dealt with adaption issues which have received only limited attention in the biomonitoring literature. Although the species used in the examples from Paper No. 16 may not be representative of all aquatic organisms, the insights provided by the author are important to biomonitoring design and data interpretation.

Q. Paper No. 17*: "Lemna as an Indicator of Water Pollution and the Absorption of Heavy Metals" by Y. Naus, M. Kugimoto, O. Tanaka, and A. Takimoto (Japan)

This paper, presented by Nasu (Japan), advocated the use of the floating aquatic plant, Lemna, as an indicator of water pollution, particularly heavy metals, Lemna is known to be sensitive to heavy metals but experimental use has been limited by the availability of suitable experimental techniques for toxicity evaluation. The authors described a plate technique which allowed evaluation of heavy metal accumulation (Zn, Cu, Cd, As, and Mn) in the fronds of Lemna. The plant was found to rapidly absorb and accumulate cadmium and can be used to monitor heavy metals alone or in mixtures. Toxicity results were not always concentration related, response may be due to other factors such as pH.

The use of Lemna as a test system allowed the monitoring of several responses ranging from metal accumulation to various growth parameters. The insights gained from this paper for biomonitoring included the recognition that it is important to have multiple response measures to allow a comprehensive assessment to toxicant effects. Of particular utility in this paper was the results reported for the joint toxicity of a number of heavy metals.

R. Paper No. 18*: "The Application of an Algal Assay to Assess Toxicity and Eutrophication in Polluted Streams" by T. Kallqvist (Norway)

This paper used algal assay techniques to assess the presence of sewage and industrial discharges. The author argued that chemical analysis may not adequately describe the complex water quality conditions of urban streams and rivers. The use of Selanastrum capricornutum algal assays allowed differentiation of locations influenced by sewage and identified locations where toxic discharges existed.

The author concluded that algal assays are a valuable supplement for normal chemical monitoring, providing valuable information to water quality management programs. The sensitivity of algae to toxicants allows the use of algal assays when the nature of the toxicant is unknown or there are multiple toxicants present. Algal assays can also be used as a general surveillance tool.

S. Paper No. 19*: "Microbial Mutagenicity Testing of Water Samples" by P. Wilcox and H. Horth (United Kingdom)

In this paper, Wilcox (United Kingdom) reviewed the efforts made at the Water Research Centre, Medmenham, to evalute the toxicity of drinking waters. The objective is to evaluate the presence of potentially carcinogenic substances, the nature of these substances, and determine if the substances are due to contamination from domestic or industrial discharges. The authors used the Ames assay with Salmonella typhimurium. Using an exposure in the liquid phase, the authors were also able to evaluate feeding-type effects.

The authors found some mutagenic activity in finished drinking water samples from the United Kingdom and a positive correlation between chlorination and mutagenic activity. The mutagenic activity was present in waters from industrialized as well as non-industrialized sites. The authors concluded that the mutagenic compounds were produced by chlorination.

T. Paper No. 20*: "The Bacillus subtilis Microsome Rec-assay for the Detection of Presence of Mutagens in Waters of a Municipal Wastewater Treatment Plant" by S. Matsui (Japan)

The author reviewed a series of experiments to evaluate the presence of mutagens in effluents from both primary and secondary municipal wastewater treatment. The author used the Bacillus subtilis/microsome rec-assay, a DNA repair deficient bacteria system which is sensitive in liquid cultivation. By comparing turbidities in test cultures, a R50 (50% reaction) concentration can be determined. By applying probit theory and target theory, the author developed a model to assess mutagenic effect.

Using the rec-assay, the author found mutagenic repsonse from all samples collected at the Kanazawa City WTP. The author classified responses as strong mutagenic, mutagenic, no mutagenic effect and reverse effects.

COMMENTS:

Paper Nos. 18 through 20 argued for the use of several biological surveillance methodologies to supplement, and possibly replace, normal chemical surveillance and monitoring. The algal assay and various bacterial mutagenicity analysis techniques provide a set of useful tools to identify both the sources and effects of toxic or mutagenic discharges. The data provided by these biological surveillance techniques may or may not relate directly to effects at higher levels of ecological organization. For example, the algal assay may provide valuable information on eutrophication and may be used for ecological interpretation, while the bacterial mutagenicity assays are more limited in extrapolation capability but do give indication of specific effect types. Both types of techniques are widely used in the United States.

U. Paper No. 21*: "Compliance Biomonitoring--Standard Development and Regulation Enforcement Using Biomonitoring Data" by E. E. Herricks and D. J. Schaeffer (U.S.A.)

This paper, presented by Herricks (U.S.A.), provided several elements of a summary for the conference and when combined with the closing remarks of Beverson (United Kingdom), concluded the conference. The authors of this paper suggested that the use of biomonitoring or surveillance data in regulatory programs requires a reassessment of programmatic approaches and objectives. The authors identified two general data types, bioassay data from experimental studies and bioassessment data from field descriptive studies. The authors provided summaries of the types of test systems used in compliance biomonitoring and identified the characteristics of bioassessment data. The authors then provided a set of criteria for selection of biomonitoring approaches and a decision tree for implementation of compliance biomonitoring programs.

4. CRITIQUE OF SESSION

The Freshwater Biomonitoring Conference spanned a range of issues critical to biomonitoring and provided a forum for scientists from over 10 countries to exchange views on these issues. Of particular interest was the early emphasis on the use of biological indices for surveillance and biomonitoring. The issue of how to analyze complex data sets as well as the procedures for generating data for surveillance programs will continue in biomonitoring. The keynote address and Paper Nos. 4 and 21 stressed the need to carefully review data collection programs with the objective of optimizing data collection efforts. Paper No. 6 suggested that the diversion of funds saved from wasted biomonitoring might be applied to conservation efforts. The papers dealing with biomonitoring techniques, both field collection procedures and toxicity or mutagenicity analyses, represented a good cross-section of state-of-the-art biomonitoring approaches.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

Present USEPA standard development and NPDES permit program activities are emphasizing ambient biological condition analysis. Receiving-stream conditions are being used to assess the adequacy of standards and as a basis for developing procedures which can take advantage of natural stream assimilative capacity in developing permit limits. This conference should provide a valuable reference for those activities, and the papers dealing with the use and optimization of biomonitoring efforts should prove to be of direct value in developing water quality based standards and permit limitation implementation.

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*Published papers are indicated by an * in the session summaries.

1. SESSION

A. Days: September 20-22, 1984
Location: Bilthoven, The Netherlands

B. Theme of Session: Water Virology Seminar (Meeting of IAWPRC Study Group on Virology)

2. REVIEWER

A. Name: Mark D. Sobsey

B. Position and Affiliation: Professor of Environmental Microbiology, University of North Carolina, Chapel Hill, North Carolina (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

The Water Virology Seminar was a three-day meeting of the IAWPRC Study Group on Virology held as part of the IAWPRC 12th Biennial Conference on Water Pollution Control. Five virology papers were also presented in a regular technical session on Wednesday, September 19, in Hall 2 from 11:00 a.m. to 4:00 p.m. in RAI Conference Center in Amsterdam (i.e., Paper Nos. C-53, C-54, C-55, C-56, and C-57). The Water Virology Seminar consisted of oral papers, posters and technical visits to virology facilities in The Netherlands. The formal and poster sessions were not arranged entirely by specific themes or topics. For continuity and convenience in this report, both oral and poster papers are arranged into the following four major topics or themes: (i) occurrence and significance of enteric viruses in drinking water, (ii) reduction of viruses in water and waste treatment processes, (iii) survival of viruses in water and other environmental milieu, and (iv) methods for virus detection in water.

A. Occurrence and Significance of Viruses in Drinking Water

Paper No. C-57: "Occurrence of Viruses in Treated Drinking Water in the United States" by E. W. Akin (U.S.A.)

Previously published data on virus isolations from drinking water in the U.S.A. were reviewed. Although enteric viruses were isolated from some U.S.A. drinking water supplies over the last 15 years, such isolations were usually associated with untreated or inadequately treated water supplies or they were suspected of being due to extraneous contamination of the samples introduced during processing and analysis. Surveys for enteric viruses in high quality drinking water supplies in the U.S.A. by the U.S. E.P.A. have consistently yielded negative results. It was concluded that viruses probably do occur at low levels in some drinking water supplies in the U.S.A. However, the frequency and health implications of virus occurrence in U.S.A. drinking water supplies remains uncertain. The important role of adequate disinfection to minimize viral contamination of drinking waters was noted.

Although no new data were reported, this paper is a valuable summary of the information available on virus occurrence in drinking water supplies of the U.S.A. It documented the relatively limited effort made in the U.S.A. to survey drinking water supplies for enteric viruses. During the discussion it was noted that over the last two decades, several European countries have made much greater efforts to determine virus occurrence in drinking water supplies.

Paper No. 1: "Detection of Rotavirus in Treated Drinking Water," by B. H. Keswick, C. P. Gerba, J. B. Rose and G. A. Toranzos (U.S.A.)

This paper, presented by Rose (U.S.A.), gave the results of a two-year survey for indigenous rotaviruses in the raw, partially treated and finished water of a municipal treatment plant in a Latin American country. A conventional treatment scheme consisting of coagulation-flocculation, sedimentation, sand filtration and chlorination produced finished water from a heavily polluted surface water source. Twenty-five percent of the finished water samples (7 to 756 litres in volume) contained rotaviruses. Rotaviruses were found with greater frequency in the rainy season, when finished water quality was poorer, than in the dry season. In some cases rotaviruses were found in finished water samples meeting existing standards for coliform bacteria and turbidity and having free chlorine residuals. However, these samples did contain fecal streptococci, thus suggesting that fecal streptococci may be a better bacterial indicator of sanitary quality than coliforms.

The findings of this important paper demonstrated that conventional treatment of poor quality source water may not result in adequate removal of rotaviruses. Because of the growing use of poor quality source waters in the U.S.A. and elsewhere, the findings of this study suggested that greater emphasis must be placed on the quality and protection of raw water sources in order to minimize viral contamination of finished drinking water.

Paper No. 3: "Analysis of Tap Water for Viruses: Results of a Survey" by N. Guttman-Bass and B. Fattal (Israel)

The results of a 1.5-year survey for enteric viruses in 111 samples of drinking water (100 or 300 litres in volume) from 30 rural communities in Israel were presented by Guttman-Bass (Israel). Three samples from three closely situated communities having water of generally good bacteriological quality were virus-positive. These communities used either untreated ground water, treated, chlorinated water from the National Water Carrier, or a blend of these. Although coliform bacteria were present in all three virus-positive samples, there was no consistent relationship between the occurrence of viruses and the levels of coliforms. Of these three samples, one met coliform standards, a second was provisionally acceptable (coliform retest required) and the third was unacceptable for coliforms.

This is yet another important paper providing evidence of at least sporadic viral contamination of public drinking water supplies that generally meet existing bacteriological and other drinking water quality standards. As in the previous paper, the public health significance of such findings is uncertain. During the open discussion of this paper, the authors indicated that further investigations, including epidemiological studies, are planned for the settlements served by these supplies in order to determine if the presence of viruses in drinking water can be related to health effects (morbidity) in the population.

Paper No. 4: "Viruses and Bacteria in a Chalk Well" by J. S. Slade (United Kingdom)

This is a third study presented at this meeting in which enteric viruses were found in high quality, finished drinking water. In this case human enteroviruses were detected in raw (ground water from a chalk aquifer) and treated (chlorinated; 1 mg/L free residual after 15 minutes, pH 7.2) samples of 250 to 10,000 litres in volume collected over a six-month period. Both the raw and treated water were of excellent bacteriological and organoleptic quality. The finding of viruses in the absence of coliform bacteria was tentatively attributed to: differences in the ability of viruses and bacteria to penetrate through the fine pores of the chalk soil; possible protection of viruses by small chalk particles with which they might be associated; or unusual resistance of the viruses to chlorine. However, the precise reasons for viral presence and persistence in the absence of coliform bacteria were not specifically identified in this study. When chlorine residuals were increased to 1.5 to 2.0 mg/L, viruses were no longer found in the treated water. Based on the results of this study, the author questioned the adequacy, with respect to viruses, of WHO guidelines for drinking water chlorination (0.5 mg/L of free residual after 30 minutes). During open discussion, there was speculation about the high hardness of this water (322 mg/L as $CaCO_3$) and its possible role in viral persistence, but no definitive insights into the reasons for viral persistence emerged.

Paper No. 5: "Detection and Health Risk Associated with Low Virus Concentration in Water" by P. Payment and M. Trudel (Canada)

This paper, presented by Payment (Canada), dealt with removal, presence and public health significance of enteric viruses in conventionally treated drinking water produced from sewage-polluted surface water at seven plants in Quebec, Canada. Nine percent of 138 finished water samples (1000 litres in volume) from these supplies were virus-positive during a one-year survey. Virus reductions occurred at each stage of treatment, including prechlorination, coagulation-flocculation-sedimentation, filtration, ozonation and final chlorination. Average virus concentrations in treated water were 0.6 infectious units per 1000 litres after chlorination and 0.3 infections units per 1000 litres after ozonation. Virus reductions by complete treatment ranged from 90% to 99.998% overall. In most instances finished water met all existing drinking water standards, including those for turbidity and coliform bacteria. This study again demonstrated that enteric viruses can be present at low concentrations in finished drinking waters produced by conventional treatment of polluted surface waters, despite the fact that the finished water meets all applicable quality standards and contains free residual chlorine.

The data from this survey were considered in an effort to estimate health risks from ingestion of low levels of viruses in drinking water. In making this estimate, four major risk factors were considered: the numbers of viruses in the water (viral density); the human infective dose of the viruses; the virulence of the viruses (the percentage of infected people becoming ill); and, the volume of water ingested. Assuming a virulence of 10%, consumption of 1 L person-d and a virus density of 0.1 infectious unit L, the probability of becoming ill was estimated at 1%. On the basis of this analysis, the authors concluded that water containing no viruses in 10 litres provides an acceptably low level of risk of viral illness.

Although this study contributed important new information about virus occurrence in conventionally treated drinking water produced from fecally contaminated surface waters, the risk assessment analysis was cursory and the conclusions about the "acceptability" of risks of viral illness from water containing low levels of viruses were not compelling. There is a need for more thorough examination and analysis of health risks associated with drinking water containing low levels of viruses, including careful epidemiological studies to complement virus surveys of water supplies.

Poster No. V-5: "Failure to Detect Cytopathic Enteroviruses in Drinking Water" by R. Morris and D. N. Sharpe (United Kingdom)

Virological examinations of 284 samples of drinking water (sample volumes of up to 1000 L) were conducted over a three-year period at 265 locations within the Severn-Trent Water Authority. No viruses were found in the total volume of 135,000 L examined. Although it is reassuring to find no viruses in treated municipal supplies such as those surveyed here, the authors caution that low level, sporadic viral contamination could not be ruled out (see Poster No. V-1 below).

Poster No. V-8: "Detection of Hepatitis A Virus (HAV) in Drinking Water" by M. D. Sobsey, S. E. Oglesbee and D. A. Wait (U.S.A.)

In the first part of this paper, Sobsey (U.S.A.) described the development and evaluation of methods to concentrate HAV from drinking water. These methods were then applied successfully to detect and quantify HAV in fecally contaminated, untreated shallow ground water used as water supply in households of a rural western Maryland community during a community-wide outbreak of hepatitis A. The household water supplies were grossly contaminated with fecal wastes as indicated by their high levels of total and fecal coliform bacteria. This is the first report of the detection and quantitation of HAV in an infectious form in fecally contaminated drinking water.

Poster No. V-14: "Some Experimental Discussion of Accuracies in Quantitative Virus Assessment for Water Supply" by H. Sumitomo, A. Kimura, T. Nakano, M. Ozaki and J. Imai (Japan)

Using both a case history and theoretical model approach, an attempt was made to determine the relative risks of viral illness or cancer due to trihalomethanes (THM) under various alternative conditions for chlorinating contaminated drinking water supplies. When the analysis was applied to a large raw surface water source used as a drinking water supply in Japan, the risk of cancer from THM exceeded the risk of virus illness only when the water was both pre- and post-chlorinated with 10 mg/L of chlorine. At lower levels of pre- and post-chlorination, the risk of viral illness always exceeded the risk of cancer from THM.

This paper is interesting because it attempts to compare health risks from two "competing" problems: excess THM levels when using high levels of chlorine and excess virus levels when reducing chlorination. However, the case history data, assumptions and theoretical analyses used here were unreliable, thereby making the results of the analysis suspect. The statistical model used to quantify relative health risks is questionable, because its validity or appropriateness has not been verified for either viruses or cancer from THM. The paper is useful in the sense that it may prompt others to make such comparative risk assessments with better data and better models.

B. Reduction of Viruses by Water and Waste Treatment Processes

Paper No. C-54: "Inactivation of Hepatitis A Virus, Other Enteric Viruses and Indicator Organisms in Water by Chlorination" by W. Grabow, P. Coubrough, C. Hilner and B. W. Bateman (South Africa)

In this paper Grabow (South Africa) presented the results of controlled laboratory studies on the inactivation of hepatitis A virus, poliovirus type 2, coxsackievirus B5, reovirus type 3, simian rotavirus SA11, coliphages MS2 and VI, *E. coli*, *Strep. faecalis* and *Mycobacterium fortuitum* in tap water and sewage effluent by chlorine primarily in the combined form. In general, HAV was more resistant to chlorination with combined residuals than were most enteric viruses and the indicator bacteria (except *M. fortuitum*). The authors suggest that current methods for determining the virological quality of water are deficient because they do not detect HAV. They also suggest that the virological safety of chlorinated waters can be monitored by measuring an array of practical microbial indicators.

This study contributed important new information on the relative resistance of HAV to combined forms of chlorine. The finding that HAV is more resistant to combined chlorine than were the usual indicator bacteria serves to further emphasize the previously recognized deficiencies of bacteria as indicators of the virological quality of water.

Paper No. 10: "Bacteria and Viruses in Anaerobically Digested Sludge: Influence of Physical and Chemical Treatments on Survival and Association with Flocs under Laboratory Conditions" by S. R. Farrah, P. R. Scheuerman, R. D. Eubanks and G. Bitton (U.S.A.)

This paper, delivered by Farrah (U.S.A.), presents some new and useful information on the inactivation and fate of enteric bacteria and viruses in anaerobically digesting sludge. Various physical and chemical treatments were used to determine bacteria and virus association with sludge solids and the role of predation by protozoans on the survival of bacteria and viruses. Sludge flocs had a high affinity for viruses (poliovirus type 1 and coxsackievirus B3) but only a limited affinity for bacteria (streptococci and salmonella). Using various physical and chemical treatments of the sludge, it was shown that unadsorbed bacteria were rapidly eliminated by active protozoan predators. Treatments that removed protozoans or reduced their activity resulted in greater bacterial persistence. Virus reductions were not greatly influenced by the presence or absence of active protozoans, and, therefore, virus reductions must occur by some other mechanism(s).

This study was a useful contribution because it demonstrated differences in the behavior and fate of enteric bacteria and viruses in anaerobically digesting sludge. Furthermore, it provided additional evidence for the important role of protozoan predation in reducing bacteria levels during sludge digestion. However, the mechanisms of virus inactivation in sludge digestion were not elucidated, and the authors did not consider the findings of previous studies on the mechanisms of virus inactivation in digesting sludges.

Paper No. 11: "Virus Inactivating Effect of Anaerobic Mesophilic Digestion of Municipal Sludge without or with Different Preceeding Types of Treatment" by M. Leuze, M. Saier, K. Koch and J. Wekerle (Federal Republic of Germany)

Wekerle (Federal Republic of Germany) presented the results of studies on the survival of three representative enteric viruses, i.e., bovine parvovirus, bovine enterovirus and reovirus type 1, in a pilot-scale mesophilic anaerobic digester operated under different temperature and residence time conditions and with or without pre- or post-pasteurization of the sludge. Some of the initial parvoviruses added to the raw sludge survived sludge treatment under most operating conditions. Greater parvovirus reductions were achieved at longer residence times and with pasteurization. Complete elimination of parvovirus was achieved only with 20 days of conventional digestion followed by pasteurization. Bovine enterovirus and reovirus were completely inactivated by conventional digestion for eight or 20 days with or without pasteurization.

This study was not especially new or unique because virus inactivation by sludge digestion has been previously studied by others under both laboratory and field conditions. One contribution of this study is in the choice of viruses used, as some of them have not been previously studied in sludge digestions. However, the results obtained for bovine enterovirus and reovirus were generally consistent with those of previous studies with other enteric viruses. The greater persistence of parvovirus in sludge digestion and pasteurization was not surprising, considering the well known thermostability of parvoviruses.

A weakness of the study was inadequate analysis of the data in order to quantify the kinetics of inactivation of each virus under the operating conditions used. Such data presentation would have greatly improved the quality of the paper.

This study fails to shed much light on the apparent discrepancy between the results of laboratory and field studies on virus inactivation by sludge digestion. It has been shown previously that extensive virus inactivation can be achieved in laboratory studies on sludge digestion, but less extensive virus inactivation seems to occur under field conditions. The authors suggest that short-circuiting in full-scale plants may account for the less extensive virus inactivation previously observed. In their pilot plant, no such short circuiting occurred. However, this difference was conjectural because they did not treat this issue experimentally in their studies.

Poster No. V-1: "The Influence of Isoelectric Point on the Inactivation of Viruses by Chlorine" by G. R. Taylor and M. J. Butler (United Kingdom)

The isoelectric points (pH values at which zero surface charge exists) for poliovirus type 1 and coliphase f2 were measured and the effect of pH on the inactivation of both viruses by free chlorine was determined under controlled laboratory conditions. It was hypothesized initially that the effect of pH on chlorine sensitivity of the viruses could be explained and interpreted on the basis of viral isoelectric points (pI). Coliphase f2, which had a single pI of 4.25, became more sensitive to chlorine as the pH fell below 7. Poliovirus, which has a major pI at 6.5 and a minor pI at 4.0, was most sensitive to chlorine near its major pI of 6.5 Thus, there was no apparent relationship between chlorine sensitivity of the viruses at different pH levels and their pIs.

Although the hypothesis was not supported, additional work should be done with more viruses in order to further confirm or refute it. Indeed, it may be useful to examine existing data available in the scientific literature to determine if such relationships exist.

Poster No. V-6: "Behaviour of Coliphages in Oxidation Ponds" by T. Omura, H. K. Shin and A. Ketratanakul (Japan)

Both laboratory and field studies were done on the behavior of coliphages in oxidation ponds. In field studies on a facultative pond (eight-day detention time) and a maturation pond (20-day detention time) in series, the levels of coliphages, *E. coli*, *C. freundii* and *Klebsiella* sp. were reduced at similar rates and extents in both ponds. In laboratory studies, it was found that coliphages in sewage could reduce the levels of *E. coli*, *C. freundii* and *Klebsiella* sp. at temperatures of 25, 30 and 37°C.

This study added little new or useful information on the behavior and fate of viruses in oxidation ponds. The finding that both coliphages and coliform bacteria were reduced by >99% in full-scale oxidation ponds was consistent with previously published data. The laboratory studies shed little light on the behavior and fate of coliphages in oxidation ponds because the experimental design and operation were poor models for full-scale ponds.

Poster No. V-11: "Study of Indigenous Virus Removal at Different Stages in a Drinking Water Plant Treating River Water" by F. Agbalika, P. Hartemann, J. C. Joret, A. Hassen and M. M. Bourbigot (France)

Virus removal efficiencies of unit processes in a water treatment plant using contaminated river water containing 10 to 146 infectious units/1000 L were determined in a seven-month survey. Treatment consisted of pre-ozonation, storage, coagulation-flocculation-sedimentation, filtration, second-stage ozonation, activated carbon adsorption, final ozonation and chlorine dioxide disinfection. Virus reductions were approximately 89% after pre-ozonation, 77% after coagulation-flocculation-sedimentation and 55% after filtration. No viruses were detected after second-stage ozonation in sample volumes of 550 to 1000 L. Quantitative virus reductions for other unit processes could not be estimated reliably due to the relatively low virus levels in the raw water, the small number of samples and short duration of the survey.

Although there were considerable virus reductions through the treatment plant, the absence of viruses in the finished water must be interpreted with caution because of the limited scope and scale of this survey. For this reason, the study provided only a modest amount of new or useful information about virus reductions by full-scale water treatment processes and systems.

It is interesting to note that the treatment system described here for a contaminated surface water source is more extensive than that usually employed in the U.S.A. The use of such extensive treatment for heavily polluted surface waters in order to better control viruses and other pathogens in finished drinking water deserves greater consideration in the U.S.A.

C. Survival of Viruses in Water and Other Milieus

Paper No. C-56: "Factors Controlling the Survival of Viruses in Groundwater" by M. V. Yates and C. P. Gerba (U.S.A.)

Gerba (U.S.A.) presented the results of laboratory studies on factors controlling the survival of MS2 bacteriophage in groundwater samples obtained from throughout the U.S.A. Groundwater samples were seeded with virus and incubated at the temperature of the native ground water to determine virus survival over time. When the survival data were analyzed for their relationships to the physical and chemical quality of the water, temperature and calcium hardness were the most important factors that correlated with virus inactivation.

The results of this study supported those of previous studies showing that temperature was the most important factor influencing virus survival in water. The finding of greater virus inactivation in groundwater with higher calcium hardness has not been previously reported and deserves to be further examined with other viruses and ground waters. Furthermore, the means by which calcium hardness contributes to virus inactivation in water should be elucidated.

Paper No. 12: "Detection and Stability of Enteric Viruses in Sludge, Soil and Ground Water" by P. H. Jorgensen and E. Lund (Denmark)

Lund (Denmark) presented the results of a field study on the survival of indigenous enteric viruses in digested sludge applied to soil and in the soil and underlying ground water of the application site. In addition, laboratory studies were done on the survival of coxsackievirus B3 (CB3), echovirus type 7 (E7) and adenovirus type 1 (Ad1) in soil and ground water. In the field study viruses were detected in the applied sludge after 21 but not 22 weeks. No viruses were detected in six 50-g soil samples from the site five weeks after sludge application. Ground water samples from the application site were virus negative when sample volumes were 5 L, but one of four 30-L samples collected 11 weeks after sludge application was virus-positive. In laboratory studies CB3, E7 and Ad1 were inactivated slowly in ground water or soil incubated at 4 to 7°C, with no more than 1 to 2 $\log_{10}$ reductions in nine weeks. Virus adsorption to sandy loam soil further protected viruses from inactivation, with only a 1 $\log_{10}$ virus reduction in about 20 weeks.

This study contributed some additional information to the existing scientific literature on virus survival in sludges, soil and ground water. Its findings supported the results of previous studies showing that enteric viruses can persist for considerable periods in sludges, soils and ground waters at low temperatures. The results are also consistent with previous studies showing relatively little virus migration from applied digested sludges into underlying soil or ground water.

Paper No. 2: "Rotavirus Survival in Raw and Treated Waters and Its Health Implications" by S. A. Sattar, R. A. Raphael and V. S. Springthorpe (Canada)

Sattar (Canada) described studies on the survival kinetics of a model rotavirus (calf) in seeded raw water (Ottowa River) and finished drinking water at 4 and 20°C under laboratory conditions. Rotavirus survived longer in finished water than in raw water and at 4°C than at 20°C. A 99% (2 $\log_{10}$) virus reduction required >64 days at both temperatures in tap water, but only 10 days (at 20°C) or 32 days (at 4°C) in raw water. The authors concluded that rotaviruses survive long enough in raw and finished water for the water to be a significant vehicle for their spread.

This study provided new data on the survival of calf rotavirus in raw and finished waters, thereby supplementing the limited existing data on the survival of simian rotavirus and other rotaviruses in raw and finished waters. The results were generally consistent with those of previous studies.

Paper No. 13: "Interactions between Biotic and Abiotic Factors and Virus in a Water System" by R. Walter, H. Grahneis J. Durkop, and L. Broschinski (Federal Republic of Germany)

Walter (Federal Republic of Germany) described a three-year survey on enteric virus levels as well as physical and chemical contaminants in a large European river receiving sewage and industrial wastes from multiple sources and used for drinking water supplies. Enteric viruses, including rotavirus and hepatitis A virus antigen in some cases, were detected in 82% of sixty-two 10-L samples of river water. Statistical analyses revealed that virus levels were negatively correlated with water pH and nitrate levels and positively correlated with ammonia levels.

The findings of this study were not unique or unexpected for a river receiving considerable amounts of sewage and other wastes. The results were generally consistent with those of previous studies on enteric virus contamination of river and other surface waters receiving sewage discharges and the relationships of viruses to chemical indicators of sewage contamination.

Poster No. V-4: "Detection of Indigenous Enteric Viruses in Raw Sewage Effluents of the City of Athens (Greece) during a Two Year Survey" by V. Krikelis, N. Spyrou and C. Serie (Greece)

Krikelis (Greece), described a two-year survey of indigenous enteric virus levels in raw sewage of Athens, Greece. Virus levels were in the range of 10^2 to 10^3 infectious units L. This study added little in the way of new or unique information on indigenous enteric virus levels and types in raw sewage, and the results were consistent with those of previous studies of this kind. However, this is the first report of its kind from Greece, and it demonstrated the growing worldwide concern about and interest in enteric virus contamination of the water environment.

Poster No. V-9: "Examination of the Penetration of Enteric Viruses in Soils under Simulated Conditions in the Laboratory" by P. H. Jorgensen (Denmark)

Laboratory studies were done to examine the penetration of Coxsackievirus B3 (CB3) and Adenovirus type 1 (Ad1) in seeded anaerobically digested sludge through soil columns operated under either unsaturated, aerobic conditions or saturated, anaerobic conditions and dosed with simulated rain water. No viruses were detected in effluent of unsaturated, aerobic columns and the viruses penetrated only a few cm into the soil during a 28-week period. In saturated, anaerobic columns of a sandy loam soil, some viruses (1% of those in the applied water) were detected in column effluents and viruses were detected in soil material from all column depths (0 to 30 cm). However, in columns of a diluvial sand soil operated under the same saturated, anaerobic conditions, viruses were not found in column effluents, and they penetrated to a depth of only 14 cm.

The results of this study were consistent with those of previous studies demonstrating little virus movement form digested sludge into underlying soils or percolating water under unsaturated conditions, but extensive virus movement from sludges into and through porous soils under conditions of saturated flow. These findings confirmed the previously known importance of maintaining unsaturated flow and aerobic conditions in soils in order to prevent the mobilization of enteric viruses in applied sludges and the advantages of using less porous soils in order to adsorb viruses and inhibit their movement into underlying ground water.

Poster No. V-13: "Studies on the Survival of Viruses in Fully Digested Sludge after Application to Grazing Land" by A. Field and J. Sellwood (United Kingdom)

In field studies on the survival of indigenous viruses in sludges applied to land by spraying, some viruses were found to remain viable in the applied sludge, surface lying water and underlying soil for at least four to six weeks after application. More viruses were isolated in the winter months than in the summer months. The results of this study confirm previous studies demonstrating the considerable persistence of viruses in digested sludges applied to land. These findings have important public health implications for the management of sludge-receiving lands used for food crops or for pasture of domestic animals.

Poster No. V-17: "Inactivation of Hepatitis A Virus by Heat and Formaldehyde" by B. Flehmig, A. Billing, A Vallbracht and K. Botzenhart (Federal Republic of Germany)

This paper described survival of hepatitis A virus (HAV) in an aqueous solution (cell culture medium) exposed to either heat (37, 50, 60 and 70°C) or formaldehyde. After 60 minutes, $\log_{10}$ reductions of HAV titers at temperatures of 37, 50, 60 and 70°C were: none, 1, 4 and >6, respectively. These results indicate that HAV is extremely heat-resistant compared to other enteroviruses. Achieving a 5 $\log_{10}$ reduction of HAV by formaldehyde concentrations of 0.0088, 0.0175 and 0.035% required contact times of 48, 24 and 12 h, respectively, and complete inactivation (>6.5 $\log_{10}$) was not achieved. A >6.5 $\log_{10}$ reduction of HAV required 0.35% formaldehyde for 72 h.

These results on HAV inactivation by heat and formaldehyde were generally consistent with the results of recently published studies by other investigators. The data on heat resistance of HAV from this and other studies indicates that HAV is likely to persist for long periods in contaminated water, wastes or soils at ambient environmental temperatures. The data on HAV inactivation by formaldehyde will no doubt be useful in efforts to develop a killed vaccine against this virus.

D. Methods for Virus Detection in Water

Paper No. C-53: "F Specific RNA Bacteriophages in Sewage: Methodology and Occurrence" by A. H. Havelaar, W. H. Hogeboom and R. Pot (The Netherlands)

Havelaar (The Netherlands) described the development and evaluation of two genetically engineered strains of *Salmonella typhimurium* for the detection of F-specific coliphages in water and wastewater previously developed by this group. They provided evidence that the F-specific RNA phages detected by one of these bacterial hosts (WG49) were a more reliable and sensitive measure of the sanitary quality of water and a better surrogate for human enteric viruses than coliphages detected by conventional strains of _E. coli_. F-specific coliphages were consistently present at high levels (10^2 to 10^4 infectious units/mL) in sewage from a variety of sources. The authors concluded that F-specific coliphages were a promising indicator of fecal contamination and of enteric viruses and deserve further investigation for these purposes.

This study extended the previous work of this group on F-specific coliphages as indicators of fecal contamination and enteric viruses in water and wastewater. Their work is an important new development in the area of coliphage indicators which hopefully will be further pursued by this group and other investigators as well.

Paper No. C-55: "Effects of Water Quality on Microporous Filter Methods for Enteric Virus Concentration" by M. D. Sobsey, T. Cromeans, A. R. Hickey and J. S. Glass (U.S.A.)

In this paper, presented by Sobsey (U.S.A.), samples of water seeded with known amounts of model enteroviruses were used to show that naturally occurring soluble organic matter and suspended solids in water as well as model organic matter (humic and fulvic acid) and model suspended solids (bentonite clay) interfere with virus concentration by microporous filter methods. Interference by soluble organic matter was greater than that of suspended solids. Despite observed interferences, recovery of some of the initial viruses was possible, although recovery efficiencies were reduced. Interferences were greater at the high concentrations of organics and suspended solids characteristic of natural waters and wastewater.

The results of this study confirmed and quantified previous observations that soluble organic matter and suspended solids in water interfere with virus concentration by microporous filter methods.

Paper No. 7: "Concentration of Seeded and Naturally Occurring Enteroviruses from Waters of Varying Quality by Hollow Fiber Ultrafiltration" by E. A. Bicknell, D. M. Dziewulski, L. S. Sturman and G. Belfort (U.S.A.)

Although this paper was not delivered at the meeting, a copy of the manuscript was available for review. In this study a tangential flow, hollow fiber ultrafiltration system operated in a dead-end flow mode was evaluated for concentrating poliovirus type 2 from seeded 100-L volumes of tap and river (Hudson River) water and for concentrating indigenous enteroviruses from treated and untreated wastewater. Poliovirus recoveries from seeded tap and river water averaged 148 and 35%, respectively. Naturally occurring viruses were concentrated from wastewaters.

This study extended previous work by this group on the development of hollow fiber ultrafiltration methods for enteric virus concentration from water. Although the results reported here are encouraging, the lack of portability and high cost of these ultrafiltration systems continues to limit their acceptance and use in field studies by other investigators. Enteric virus concentration from water by adsorption to and elution from microporous filters continues to be the most accepted and widely used method in the field because of its low cost, portability and validated effectiveness.

Paper No. 8: "The Recovery of Viruses from Drinking Water by Means of an In-line Electropositive Cartridge Filter" by E. M. Nupen and B. W. Bateman (South Africa)

In this paper, presented by Nupen (South Africa), electropositive Virosorb 1MDS cartridge filters were evaluated for in-line concentration of enteric viruses from 100-L volumes of drinking water. A second-step concentration procedure was eliminated by converting the filter eluate to cell culture medium and inoculating it directly into cell cultures for virus assay. Using samples seeded with poliovirus types 1 and 2, reovirus 1, simian rotavirus SA11 and coliphages, recoveries averaged 76, 63, 23, 16.5 and 31%, respectively. Poliovirus could be recovered consistently from seeded tap water samples containing only 1 to 10 infectious units. The authors concluded that this was a promising system for in-line virus detection which warranted further investigation.

This study supported the findings of a number of previous studies demonstrating that enteric viruses can be concentrated from large volumes of water conveniently and without conditioning the water by adsorbing them directly onto electropositive filters and then eluting them in a small volume of fluid.

Paper No. 9: "Concentration of Viruses from Water Using Pig Erythrocyte Ghost Cells" by R. Armon, Y. Kott and Y. Neeman (Israel)

Armon (Israel) indicated that ghost cells made from pig erythrocytes could be used as the sorptive matrix in organic flocculation procedures for concentrating viruses from water. Using small (5.0 mL) volumes of ghost cell suspension seeded with poliovirus type 1 or bacteriophages, quantitative virus recoveries were achieved by a conventional organic flocculation procedure involving acidification to pH 3.5, recovery of the floc by centrifugation and resuspension of the recovered floc in an appropriate solution.

This paper presented preliminary evidence that ghost cells are a promising alternative to beef extract and similar materials for organic flocculation of viruses from small volumes of water. However, further experiments with larger sample volumes and a wider range of viruses are needed to verify the usefulness of this procedure. In addition, it is not yet certain that ghost cells of uniform quality will be commercially available.

Paper No. 14: "Detection of Enteroviruses: An Assessment of Ten Cell Lines" by R. Morris (United Kingdom)

Ten human and simian cell lines were evaluated for their ability to detect laboratory strains of 26 enteroviruses as well as indigenous enteroviruses in wastewater effluent. BGM cells, which are widely used in water virology, gave the highest virus recovery efficiencies, followed by RD and chimpanzee liver (CL). This study confirmed that the BGM cell line is a sensitive host for detecting enteric viruses in water and wastewater and supported previous findings of the superiority of this cell line over other simian and human cell lines. The relatively poor performance of the MA104 cell line in this study was somewhat surprising, considering that other workers have previously found them to be nearly comparable to BGM. This may be explained by differences in the assay procedures of this and previous studies. In this study, the agar cell suspension plaque assay was used, while in most previous studies, monolayer plaque assays or liquid culture quantal (CPE) assays were used.

Poster No. V-15: "Detection of Hepatitis A Virus in Drinking Water by Enzyme-immunoassay Using Ultracentrifugation for Virus Concentration" by A. Schnattinger (Austria)

Large quantities of HAV antigen (10^8 particles) in seeded 10-L samples of tapwater could be concentrated to a volume of 1 mL with a recovery efficiency of about 50% by a two-step procedure involving aluminum hydroxide flocculation followed by ultracentrifugation. This is one of the first reports showing that HAV can be concentrated from water by methods previously developed for concentrating other enteric viruses. However, the experiments were quite artificial because an unrealistically large quantity of HAV was added to a relatively small volume of water. Furthermore, detection of HAV was based only on antigenicity and not on infectivity. Hopefully, further studies using lower levels of HAV, larger volumes of water and HAV assay by infectivity will confirm that HAV can be concentrated efficiently from water by these methods.

Poster No. V-16: "Genomic Analysis of RNA Viruses from Effluent" by M. T. Hodgkiss and J. W. Moodie (South Africa)

In this study a rapid method to extract RNA from reovirus and rotavirus followed by genomic analysis using polyacrylamide gel electrophoresis was employed to identify and distinguish strains of rotaviruses and reoviruses. This paper provided little new or unique information, as all of the methods have been previously developed and applied by other investigators. The main contributions of this study were the standardization of the methods and their use to identify reovirus isolates from wastewater rather than from stool specimens obtained in clinical settings.

4. CRITIQUE OF SESSION

In the opinion of this writer and many of the conference participants who volunteered their opinions, the Seminar on Water Virology was a scientific success. Some outstanding and many good papers were presented either orally or as posters. The seminar made possible the largest and most geographically representative international gathering of environmental virologists in recent years, and it provided the opportunity for considerable scientific exchange in formal sessions as well as informally.

Seven papers dealing with virus surveys of finished drinking waters were presented. In five of these papers (Paper Nos. C-57, 1, 3, 4 and 5), virus-positive samples were found in finished drinking water supplies meeting quality standards for bacteria, turbidity and other constituents and often containing free residual chlorine. These are important findings which add to a growing number of reports worldwide on virus occurrence in finished drinking water. The significance of these findings in terms of quantifiable health risks of viral infection and illness in populations consuming these waters remains unknown and certainly deserves further epidemiological study. Now that several suitable candidate locations for such virological-epidemiological studies have been identified, it is hoped that funding for such studies will be provided in the near future. The failure to detect viruses in the other two studies reported (Poster Nos. V-5 and V-11) may reflect more extensive and better water treatment, source waters with lower levels of viruses, or less extensive surveys with fewer samples.

The development of methods to cultivate hepatitis A virus and assay its infectivity in cell cultures are important new breakthroughs which now make it possible to study the detection, occurrence, survival and fate of this epidemiologically important virus in water and wastes. This progress in HAV virology was reflected in the fact that four papers on HAV in water were presented at the seminar. The abilities to recover HAV from contaminated water by conventional concentration methods (Poster Nos. V-8 and V-15) and to quantify the infectivity of the recovered virus in cell cultures (Poster No. V-8) were important new findings. These studies demonstrated that it is now possible to systematically study water and wastewater contamination by this important virus and to develop and evaluate methods to control such contamination. In this regard the laboratory study by Grabow *et al*. (Paper No. C-54, South Africa) on chlorine inactivation of HAV and other microbes is an important step in the right direction. The findings of this study, which indicate that HAV is more resistant to combined forms of chlorine than are other enteric viruses and widely used indicator bacteria (*E. coli* and *Strep. faecalis*), have important implications for the growing use of chloramines as a drinking water disinfectant. Disinfection of HAV in water is much more effective using free chlorine, to which HAV is quite sensitive, than using combined chlorine, to which HAV is quite resistant. The unusual thermostability of HAV in water (Poster No. V-7) is also an important contribution because it helps explain why HAV persists in the water environment long enough to cause waterborne outbreaks. It also suggests that future studies must be directed towards further determining the ability of a treatment process, such as disinfection, to remove or destroy HAV; controlling waterborne contamination by HAV will have to be achieved by applying effective treatment. Such studies can now be done with the aid of newly developed cultivation and assay methods of HAV.

Valuable information on the persistence of other enteric viruses in water, sludge and soil was also presented (Paper Nos. C-56, 2, 10, 11 and 12 and Poster Nos. V-9 and V-13). These studies supplement the existing scientific literature which indicates that enteric viruses often persist for considerable periods of time in the environment, especially at lower temperatures. The study on rotavirus survival in raw and finished water by Sattar *et al*. (Paper No. 2, Canada) was especially valuable because of the limited data previously available on the survival in water of this epidemiologically important group of viruses. The considerable persistence of viruses in such diverse milieu as sludges, soils and ground water (Paper Nos. C-56 and 12 and Poster Nos. V-9 and V-13) supported the findings of previous studies reported in the literature. Such findings indicated that viruses must be reduced in sludges and effluents through the use of more effective treatment processes, or that various alternative barriers must be used to prevent human and animal exposure to these viruses in the environment by such routes as contaminated drinking water, recreational water, direct contact with applied wastes or consumption of contaminated foods.

Some useful information on virus reduction by water and waste treatment processes was presented. The previously mentioned paper by Grabow *et al*. (No. C-54), in which it was found that HAV is more resistant to combined chlorine than are a number of other enteric viruses and common indicator bacteria such as *E. coli* and *Strep. faecalis*, is an important contribution to the disinfection literature. The findings of this paper provide at least a partial explanation for why HAV sometimes persists in chlorinated, finished drinking water and causes waterborne disease outbreaks. The work of Farrah et al.(U.S.A.) in Paper No. 10 was more valuable for its findings on the role of predation by protozoans in reducing enteric bacteria in digesting sludge than for its virological findings. The study by Leuze et al. (Federal Republic of Germany) in Paper No. 11 on virus reductions by sludge digestion and pasteurization was valuable primarily for its findings on sludge pasteurization. The possible role of short-circuiting as the cause of viral persistence in conventional sludge digesters as opposed to their relative lack of persistence in the pilot-plant studies of this paper deserves to be followed up by further investigation. The work of Taylor and Butler (United Kingdom) in Poster No. V-1 did not adequately answer the question asked about the relationship between viral isoelectric points and virus sensitivity to chlorine at different pH levels.

There were several important developments in virus concentration and detection methods. Reports that HAV can be concentrated from large volumes of water by adsorption to and elution from filters followed by organic flocculation (Poster No. V-8, U.S.A.) and by aluminum hydroxide precipitation (Poster No. V-15, Austria) are findings that will be useful for further investigations on HAV in water. Also important in this regard was the finding that HAV recovered from water can be quantitatively assayed for infectivity in cell cultures (Poster No. V-8, U.S.A.). The study by Nupen et al. (South Africa) in Paper No. 8 on enteric virus concentration from large volumes of drinking water by in-line electropositive filters further confirmed the value of this procedure for the virological examination of water. The paper by Sobsey et al. (U.S.A.) in Paper No. C-55 on interferences with microporous filter methods for virus concentration from water by soluble organic matter and suspended solids further documents and quantified the findings of previous studies suggesting such effects. The development of a new system for detecting F-specific coliphages in water was an important contribution which seems to overcome many of the major problems and deficiencies previously associated with the use of coliphages as indicators for enteric viruses and the sanitary quality of water in general. With continued interest in more reliable, yet technically simple, indicators of water quality, including virological quality, the development of this system seems to offer considerable promise that deserves further investigation. The value of erythrocyte ghost cells as an alternative reagent for virus concentration by organic flocculation, as presented by Armon et al. (Israel) in Paper No. 9, remains to be seen.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

Much valuable information presented at this conference is relevant to water pollution research in the U.S.A. The reports on virus isolations from finished drinking water supplies in Canada, Israel, the United Kingdom and a developing Latin American country have important implications for the possible occurrence and public health effects of viruses in American drinking water supplies. Compared to some other developed countries, there have been only limited virus surveys of U.S.A. drinking water supplies. The positive results obtained in the studies of these other countries cast serious doubts upon the nature and reliability of previous virus surveys in the U.S.A. by the U.S. E.P.A. in which no viruses were found. Previous U.S.A. studies were biased towards the examination of well-treated supplies consistently producing high quality water. However, there are many drinking water supplies in the U.S.A. producing water with varying degrees of lesser quality than that of supplies previously surveyed, yet meeting existing drinking water quality standards. Drinking water supplies representing the full spectrum of treatment systems and drinking water quality in the U.S.A. should be included in future surveys in order to characterize more completely the occurrence of enteric viruses in U.S.A. drinking water. In addition, future studies should eventually include an epidemiological component in order to determine the health risks associated with drinking water containing detectable levels of enteric viruses.

Considering the recent progress in methods to study HAV contamination of water and the recent occurrence of waterborne outbreaks of hepatitis A in treated U.S.A. drinking water supplies, it is obvious that greater efforts should be made in the U.S.A. to further study the survival and fate of HAV in water and wastewater treatment processes and under natural environmental conditions. With the report that HAV is relatively resistant to combined forms of chlorine, the current trend towards disinfection with chloramines instead of free chlorine must be reconsidered. Decisions to switch from free to combined forms of chlorine for disinfection of drinking water supplies should not be made solely on the basis of bacteriological information. HAV and other enteric viruses are more resistant to chlorine than are bacteria. Furthermore, viruses have been found in and outbreaks of viral disease have been caused by treated drinking water supplies meeting bacteriological standards.

Reports on the occurrence and persistence of enteric viruses in digested sludges have important implications for policies on sludge treatment and disposal in the U.S.A. Although there are U.S. E.P.A. regulations for disinfection of sludges within the federal sludge disposal criteria, these regulations were based on what is now decade-old information on the occurrence and behavior of viruses and other pathogens in sludges. These regulations and the criteria for them should be re-examined in light of the new information presented at this seminar and elsewhere in the recent scientific literature.

Information presented on the survival and persistence of viruses in ground water and soil also has important implications for water pollution research activities in the U.S.A. Although there are growing concerns about ground water contamination in the U.S.A. and new ground water pollution control efforts have been initiated at the Federal, state and local levels, most of the attention has been focused on chemical contaminants. However, viral and other microbial contamination of ground water due to septic waste systems, municipal systems for land application of wastewater and sludges, municipal solid waste landfill leachates and other sources of fecal wastes still occurs, as do outbreaks of waterborne viral disease due to fecally contaminated ground waters. Therefore, more attention must be directed towards the assessment and control of ground water pollution problems involving viral and other microbial pathogens.

New developments on methods for virus detection in water are also important to U.S.A. water pollution research activities. Based on the new laboratory and field studies showing that enteric viruses can be reliably and conveniently concentrated from water using electropositive cartridge filters, standardized methods for the use of these filters should be considered for inclusion in methods manuals produced in the U.S.A., including the U.S. E.P.A. Virology Methods Manual, Standard Methods and the ASTM Manual for Water. The new method developed to detect F specific coliphages in water also must be studied by U.S.A. investigators in order to determine if it is reliable and useful for determining the virological quality and general sanitary quality of water. If the usefulness and reliability of this coliphage indicator system can be confirmed in the U.S.A., it may be an attractive alternative indicator system which could eventually become widely used for monitoring and regulatory purposes and for determining the efficiency of unit treatment processes. It is an especially attractive prospect for monitoring the virological quality of water. Considering current U.S. E.P.A. efforts in the area of revised microbiological regulations for drinking water, the potential of this new coliphage indicator system deserves immediate study in the U.S.A.

1. SESSION

A. Days: September 24-25, 1984
Post-Conference Seminar
Location: Antwerp, Belgium

B. Theme of Session: Seminar on Advanced Treatment Technologies for Removal and Disposal of Micropollutants

2. REVIEWER

A. Name: Paul H. King and Raymond A. Sierka

B. Position and Affiliation: Professors of Environmental Engineering, Department of Civil Engineering and Engineering Mechanics, University of Arizona, Tucson, Arizona (U.S.A.)

3. DESCRIPTION OF SESSION PAPERS

Paper No. 1: Presidential Address by A. Van Haute (Belgium)

This opening keynote address focused on the 1983 activities of the International Water Tribunal formed to assess the extent of micropollutant discharges into the major river basins of Western Europe. In contrast to the prevailing hypothesis of the Tribunal that a simple causal relationship exists between the occurrence of micropollutants and incidence of cancer, Van Haute (Belgium) sought to describe the complexity of the interactions and to define the results of some of the more significant recent studies on micropollutant removal techniques. Of particular interest was the extended biological/physico-chemical scheme of van Rensburg and co-workers (Prog. Wat. Tech., 12:537-552, 1980) in which a multiple barrier effect was brought about and a superior water quality was produced.

Van Haute (Belgium) also described several natural removal mechanisms for micropollutants in flowing streams, with particular significance attributed to adsorption onto suspended organic and inorganic matter. Nonetheless, he did not minimize the danger of micropollutants, citing uncertainties relative to health hazard limits, in particular long-term biomagnification effects, and problems associated with the complexity of analysis and hazard assessment procedures.

Paper No. 2: "Removal of Traces of Arsenic and Selenium by Activated Alumina" by M. Ghosh, J. R. Juan, R. Schlicher and S. M. Hornung (U.S.A.)

The work of Ghosh (U.S.A.) and colleagues on the removal of various trace metals by activated alumina is familiar to many researchers in the U.S.A. This paper presented an overall summary of their research on removal of arsenic and selenium by adsorption of the negatively charged species arsenite, arsenate, selenite, and selenate on activated alumina. The process is highly pH sensitive with best performance achieved at low pH levels. Cations, especially Ca (II), enhance adsorption while a variety of anions such as sulfate, silicate and phosphate inhibit performance. Both batch and column studies were employed. Spent beds of aluminate were successfully regenerated using a 0.5% solution of caustic soda.

In the discussion of this paper, it was noted that the impact of the process would most likely be evident in smaller communities where alternative water sources would be unavailable. At Gila Bend, Arizona (U.S.A.), the process is used, but the primary goal is fluoride removal. Arsenic and selenium removal is compatible with this process, but fluoride ion is preferentially removed by the activated alumina. The ultimate disposal of regenerate remains a largely unsolved problem. In the opinion of the reviewers, this problem must be addressed and an adequate solution indicated before widescale adaptation of the treatment scheme will be feasible.

Paper No. 3: "Two Options for Treatment of Acidic Organic Industrial Wastes" by N. Millot, N. Dalga and N. Foussard (France)

This paper described two diverse methodologies for the treatment of highly acidic organic wastes (pH approximately zero) which contain COD concentrations of several hundred g/L. The first approach was to apply a high temperature and pressure oxidation (wet oxidation) process which produced between 93% and 99% oxidation for three industrial wastes. The second technique consisted of mixing an adsorbent into the sludge to immobilize the organic content, followed by drying and solidification. Landfill disposal is proposed for the solidified waste.

The authors concluded that wet oxidation of three industrial wastes (i.e., phytosanitary industry containing sulphoquinoleine derivatives, pharmaceutical effluents containing non-chlorinated solvents dissolved in hydrochloric acid, and phenol derivative residues in hydrochloric acid in the presence of aluminum salts) produced an effluent of "low organic content, which makes it possible to envision the application of conventional biological or physical-chemical treatment before disposal." In the discussion, it was pointed out that if biologically treated, the oxygen demand of these treated effluents would pose a high demand on the oxygen transfer capability of existing treatment systems. Recently, in the U.S.A. there have been several cases of litigation involving high temperature-pressure sludge treatment and the resultant highly biodegradeable effluent which led to the production of secondary effluents not in compliance with BOD standards.

In the SOLIROC process, metal elements are converted to metal silicates with the release of silicic acid followed by polymerization of the silica gel with the metals and subsequent precipitation with base. Finally, the sludge is hardened by cementation. During this procedure, organic substances are also immobilized to reduce leachability.

The major comments in this session related to the lack of a standard leaching test by which all solidification processes could be evaluated and compared. The author agreed that an immediate international effort is required to produce such a procedure.

Paper No. 4: "Heavy Metal Removal in the Presence of Colloid-Stabilizing Material, and Complexing Agents" by I. Licsko and I. Takacs (Hungary)

In the first of two papers from the Hungarian Research Center for Water Resources Development, experiments on removal from wastewater of soluble copper, nickel, zinc, chromium, and cadmium were described. In situations where removal was impaired by colloid stabilizing agents, the authors demonstrated that this unfavorable effect could be reduced by addition of magnesium ion and upward adjustment of pH. It was postulated that the stability noted was associated with the formation of heavy metal-amine complexes and that the higher pH was necessary for breaking the complex and for subsequent satisfactory removal of the metals. The research did not appear to break new ground but did provide a substantial data base for study of systems of this type.

Paper No. 5: "Changes of Particle Size Distributions on a Fixed Bed of Granular Activated Carbon" by E. A. Shpirt and K. T. Alben (U.S.A.)

Recognizing that particle size affects both adsorption kinetics and fluid mechanisms in a packed-bed column, the authors have presented results for dynamic changes in GAC particle size distribution and list possible causes for the observed behavior.

Little work has been reported on this topic, and high interest was evident in the discussion. While the data generated related to an activated carbon produced from coal, attendees were concerned with the behavior of wood, lignites and coconut-shell absorbents. Typically, these are softer materials and have a tendency to powder more readily than coal-based activated carbons. The adequacy of abrasion number testing as currently practiced was likewise questioned. The authors did not report or correlate adsorption performance or pressure drop buildup over the 60 weeks of monitored performance, thus diminishing the potential application of their research.

Paper No. 6: "Treatment of Tar Sand Wastewater with Activated Carbon, Ozone and Reverse Osmosis" by Raymond A. Sierka and Paul H. King (U.S.A.)

In situ processing of tar sands in the western U.S.A. produces wastewater to oil ratios of 2.9 to 5.4, depending on the recovery process employed [i.e., sequenced forward-reverse combustion (TS-1S) or steam flooding (TS-2C)]. This wastewater has potential as a recycleable resource, since process water is generally nonexistent at the tar sand recovery site. If recycling is not indicated, the wastewater must be treated prior to disposal to the local environment. The authors first presented data on the treatment of these two wastewaters by six commercially available activated carbons. They showed that little adsorption occurred for TS-2C wastewater. After ferric chloride pretreatment of TS-1S wastewater at 350 mg/L, an excellent (TOC of 27.0 mg/L) effluent was produced which upon further treatment with activated carbon showed TOC reduction to less than 4.9 mg/L in all cases. This water was of sufficient quality to be used for make-up water for low-pressure steam boilers. Ozonation of TS-1S wastewater after pretreatment by either foam fractionation or chemical treatment with ferric chloride, then activated carbon, yielded treated wastewaters with a TOC of less than 1.2 mg/L in a colorless and odorless condition. Ozonation of TS-2C wastewaters was unsuccessful in that unrealistic kinetic rates of organic destruction were observed.

TS-2C wastewater was readily treated by reverse osmosis. Of the four types of membranes investigated, a thin film ether-urea composite membrane operated in two stage modes gave the best performance. The first stage employs a feedwater pH of 6.9 to maximize inorganic rejection while obtaining 90% organic rejection. In the second stage, the feedwater pH is elevated to 10.0, then processed to remove virtually all of the remaining organics. Overall, 97% inorganic and 98% organic rejections were achieved. The research gives initial screening information needed for the potential development of acceptable treatment processes for the tar sand industry. A major drawback in the work is the lack of membrane fouling data.

Paper No. 7: "Water Treatment by Means of Activated Carbon, Prepared from Locally Available Waste Materials (II)" by H. Keirsse, F. van Hoof, J. Janssens, and A. Buekens (Belgium)

The authors presented data on the production of activated carbon from sawmill residues in a reactor employing 60-80 mesh sand as the fluidized media. The product activated carbons were evaluated using the following procedures: iodine number, methylene blue number, phenol value, tannin value and BET-surface area. Also, the best activated carbons were evaluated for their adsorptive capacity for phenol, pentachorophenol, p-toluenesulfonate, and dodecylbenzenesulfonate. Comparison with a commercially available activated carbon (Chemviron F-400) demonstrated the superiority of the latter to the sawmill waste activated carbons. However, the best sawmill carbon proved superior to other commercially available activated carbons. Generally, the Freundlich model was not applicable, and more complex curve fitting was required to describe the adsorption data. The authors failed to provide insight into observed nonlinear behavior.

Paper No. 8: "Elimination of Micropollutants by $NaAlO_2$ Flocculation During Primary Treatment of Mixed Wastewater" by J. P. Vanderborght and R. Wollast (Belgium)

The efficacy of using sodium aluminate ($NaAlO_2$) for wastewater treatment was reported by the authors after they had performed two years of laboratory and field studies. Laboratory jar test experiments initially were carried out with wastewater taken directly from a sewer serving the most industrialized areas of Brussels. This same wastewater was also spiked with 2, 5 and 10 mg/L of Cd, Cr, Cu, Ni, Pb and Zn, and all four samples treated with AlO_2^- at 50 mg/L. For initial concentrations of metals greater than 1 mg/L, removal averaged 70-90%. Only Ni exhibited poor removal, with residual concentrations generally greater than 10 mg/L.

For the pilot plant runs, wastewater with intermittent inputs of heavy metals were used so that partial inhibition of subsequent biological treatment would be suspected. To test heavy metal removal, $ZnSO_4$, $NiSO_4$, $CuSO_4$, $CaSO_4$, and $CrCl_3$ in concentration equivalent to 6.0 mg/L for each species were added to the wastewater. Side-by-side comparisons with AlO_2^- additions of zero and 150 mg/L were made. The results showed excellent Zn and Cd removal with aluminate. Nickel was not affected, but Cu and Cr (III) were effectively removed. Experimental results correlated well with theory. The effluent from the pilot plant was subjected to biological treatment, and the data confirmed that the process was uninhibited by heavy metals when pretreatment by $NaAlO_2$ was carried out. The study showed careful work and adds a substantial contribution to the growing literature on this topic.

Paper No. 9: "Upgrading of a Wastewater Treatment Plant in a Chemical Factory" by P. Benedek, I. Takacs, and I. Vallai (Hungary)

An attempt to upgrade performance of an organically overloaded activated sludge treatment plant through the addition of PAC was described. Wastewater tributary to the plant stemmed from manufacture of a variety of organic chemical products, including plastics and pesticides. In spite of provisions for equalization and neutralization, wide fluctuations in influent quality were evident. PAC addition was determined to be beneficial, bringing about a 30-40%

improvement in performance as compared to a control unit. With an influent COD of about 3000 mg/L, a PAC dose of about 100 mg/L was employed and resulted in a 20-30% increase in operating costs. Sludge separation properties also improved. The work was an interesting case study but did not add significantly to the current mechanistic understanding of the potential for improvement associated with PAC additions to activated sludge reactors.

Paper No. 10: "Impact of Selected Pretreatments on the Quantity and Distribution of Organic Halide Precursors" by D. Reckhow (U.S.A.)

Reckhow (U.S.A.) gave a further report on his research, a substantial portion of which had previously been reported (Journal AWWA, 76:151-157, 1984). The author showed that in various treatment techniques, significant differences may be evident in removal of Chloroform Formation Potential or Total Trihalomethane Formation Potential as opposed to Total Organic Halide Formation Potential (TOXFP). Several organic species were identified as potentially useful surrogate parameters for TOXFP and a number of important intermediates in the organic halide production reactions were noted. Model compounds were used in an effort to elucidate some of the mechanisms in TOX production. The work is adequately summarized in the indicated reference.

4. CRITIQUE OF SESSION

The post-conference seminar examined a wide variety of issues under the general theme of micropollutant removal. While the papers were diverse in quality, they do represent a substantial body of research related to both inorganic (metal) and organic removal processes in both water and wastewater treatment. In spite of the obviously disjointed nature of the various contributions, they can be grouped into several categories.

The reports of Ghosh (U.S.A.), Licskó (Hungary) and Vanderborght (Belgium) all focused on removal of soluble heavy metals. Ghosh (U.S.A.) in Paper No. 1 shows applicability of activated alumina for arsenic and selenium removal from raw water prior to domestic use. Licskó (Hungary) in Paper No. 4 studied a wider variety of metals in wastewater in the presence of complexing agents which hinder precipitation, but indicated that sorption/precipitation can still be effectively achieved by addition of Mg^{++} and judicious adjustment of pH. Vanderborght (Belgium) also examined a large number of heavy metals in Paper No. 8 and achieved satisfactory results treating wastewater with sodium aluminate prior to conventional biological treatment. The papers of Licskò (Hungary) and Vanderborght (Belgium) are useful additions to the present literature on heavy metal removal, but do not contribute any new fundamental knowledge in this area.

The papers of Shirpt (U.S.A.) and Keirsse (Belgium) add marginally to current knowledge of activated carbon technology. The attempt by Shirpt (U.S.A.) in Paper No. 5 to model the dynamic behavior in fixed-bed carbon columns with respect to particle size changes graphically pointed out that this factor must be considered when adsorption phenomena are quantified and comparisons made among various experiments. Particle size counting techniques are increasingly more utilized and their application to this problem should receive attention. Keirsse (Belgium) pointed out in Paper No. 7 some of the ways in which starting material eventually affected properties of the activated carbon product and thus gave useful information to those considering new sources of raw material for AC production. However, raw material costs are minor in the overall scheme of activated carbon production. Obviously from their data, the surface chemistry of activated carbon produced from sawmill residues is complex. Further research into the nonlinear responses obtained by the investigators would enhance understanding of this type of adsorption and lead to better employment of activated carbon.

The contributions of Millot _et al._ (France), Sierka and King (U.S.A.), and Benedak _et al._ (Hungary) all focused on highly concentrated organic wastewaters and looked at a variety of conventional and nonconventional treatment techniques. Wet air oxidation and solidification as presented by Millot (France) in Paper No. 3 both show some promise, but critical issues such as sidestream treatment disposal from wet air oxidation and evaluation of leachate potential associated with solidification and ultimate land disposal were not adequately addressed. The report by Sierka and King (U.S.A.) in Paper No. 6 on tar sand wastewater treatment is a process-screening study that should be of use if future developments lead to the emergence of this industry. The case study by Benedek _et al._ (Hungary) in Paper No. 9 added to a growing literature on use of PAC enhanced biological treatment.

The report by Reckhow (U.S.A.) in Paper No. 10 added little to his previously published work on organic halide formation during water chlorination, but did give participants an opportunity to focus on the issue of THM and TOX formation potentials in water treatment. The sometimes stricter European standards make this work a timely addition to the thrust of the seminar.

5. SIGNIFICANCE AND VALUE TO U.S.A. WATER POLLUTION RESEARCH ACTIVITIES

The decision to employ high temperature/pressure liquid phase oxidation processes is partially controlled by the energy content of the organics in the feedwater. Highly concentrated aqueous organic solutions may be viable candidates for this treatment scheme and perhaps even produce self-sustaining reaction. This consideration may also have an implication for the organically concentrated hazardous and toxic wastewaters which will be produced when Western U.S. energy sources such as tar sands, oil shales, and coal are processed. Current research has shown these wastewaters to be difficult to treat biologically, whereas physical-chemical processes are extremely costly when utilized. The major concern, should high temperature/pressure systems find use, is the subsequent treatment of the liquid process effluent. Possible over-taxation of the oxygen transfer capability of biological treatment systems requires careful scrutiny during the design phase of such systems.

The increased tendency to concentrate highly toxic organic constituents removed from wastewaters into chemically-based sludges, some of which may be subjected to a solidification process such as that described by Millot *et al.* (France), brings about a need to develop a meaningful test of leachate potential. While batch experiments at a controlled pH level are of some significance, it would seem that the more costly and time-consuming column experiments would yield more useful data which would lead to appropriate landfill design.

CHAPTER IV

OVERVIEW OF PERTINENT CONFERENCE DEVELOPMENTS

The developments of the Conference as summarized by the selected participants are presented by major categories in this chapter. Most of the more pertinent information is presented herein.

This chapter is divided into two sections, namely, "Developments at Formal Sessions" and "Developments Outside the Formal Sessions." These two perspectives are designed to give the reader a broad overview of the Conference technical production, both in a formal and informal sense.

A. Developments at Formal Sessions

The individual reports of the formal sessions as presented previously in this document are summarized in this section. The intent is to underscore the more pertinent topical material presented in these formal sessions using a logical format. The paper identification and country of the author(s) is duly noted.

Aerobic Films

A diffusion-reaction model was shown to be a good starting point for consideration of more detailed analysis of biofilm processes such as: competition for a common electron donor among microbial populations (Paper No. C-3, Switzerland), and unsteady state caused by load fluctuations (Paper No. C-4, U.S.A.). While this conceptual view of the biofilm is accepted by researchers, it is still not being used for design (Paper No. C-1, Denmark). Organic particulates can adsorb onto biofilms, but their effect on biofilm activity (either positive or negative) is not well known (Paper No. C-1, Denmark).

Phenols at relatively low concentrations (30 mg/L) are removed completely in an aerobic fluidized bed reactor using media composed of activated carbon, cement balls, toyoura sand or silica sand; however, at influent phenol concentrations of 62 to 115 mg/L, the efficiency decreased to approximately 60% and 70%, respectively (Poster No. P-29, Japan).

Activated Sludge

A technique for measuring short-circuiting in oxidation ditches was presented (Paper No. C-16, Federal Republic of Germany).

Microorganisms grown in completely mixed systems were shown to be very different from microorganisms grown in compartmentalized systems (Paper No. C-17, France).

A strategy that uses a microprocessor for in-line equalization was demonstrated. The strategy takes into account flow rate, mass load, tank capacity, rate of change of flow, and historical loading patterns (Paper No. C-18, South Africa).

A multiple-level, or "flexible" model of the activated sludge process was presented. Effluent concentration depended on the model level, while biomass concentrations were hardly affected by model choice (Paper No. C-20, Israel, Japan).

Type 021N and *Thiothrix* have been implicated in bulking when the causative agent was any one of the number of factors, such as low dissolved oxygen in the mixed liquor, low pH, nutrient deficiency (most probably nitrogen), low organic loading, sludge age, and the septicity of the wastewater (Paper No. C-14, Denmark). *Thiothrix* and Type 021N were present in samples collected at 14 activated sludge treatment plants; however, bulking was not observed in six plants. *Thiothrix* caused bulking in only four of the eight plants where it was the dominant species. The significance of sulfide and thiosulfate oxidation and deposition of sulfur granules by these filamentous organisms to activated sludge bulking requires additional study (Paper No. C-14, Denmark).

Control of mixing patterns in aeration basins was shown to strongly determine the characteristics of an activated sludge (Paper No. C-16, Federal Republic of Germany; Paper No. C-18, South Africa). A two-stage process, i.e., the A-B process, from Germany was discussed but lacked definitive data (Paper No. C-19, The Netherlands).

Batch analysis of biomass respiration was used to determine the half-reaction coefficient and maximum specific substrate utilization rate. Organisms cultivated under 'selector-type' reactor environments exhibited significantly higher maximum specific substrate utilization rates (Paper No. C-21, Czechoslovakia).

The degradation and loss of toxic contaminants within an activated sludge system was modeled using pollutant specific Monod equations and a first-order volatilization model. Adsorption kinetics were excluded (Paper No. C-23, U.S.A.).

Simultaneous biological removal of organic carbon and nitrogen were modeled for a single-sludge oxidation ditch. Carbon oxidation, nitrification, denitrification and the presence or absence of DO and availability of alkalinity were included in the model (Paper No. C-24, Japan).

Biological Nitrification; Denitrification

A model has been developed and compared to laboratory-scale reactor data for fluidized bed nitrification (Paper No. C-29, Canada and U.S.A.).

Significant denitrification was shown to be possible in rotating biological contactors (RBCs) even though the bulk liquid contained significant dissolved oxygen. There was, however, an optimal oxygen partial pressure in the gas space at which overall nitrogen removal was maximized (Paper No. C-31, Japan).

Analysis of trace contaminants in wastewaters being treated by predenitrification-nitrification technology revealed that high degrees of removal were achieved whenever complete nitrification occurred. Thus it was suggested that the degree of nitrification could be used as a surrogate measure of trace contaminant removal (Paper No. C-32, Canada).

A review of the literature and a consideration of theoretical concepts suggested that elevated nitrite levels are likely to occur in biologically treated effluents more frequently than had heretofore been thought possible (Paper No. C-33, U.S.A.).

Fluidized bed biological denitrification has been modeled. The model includes the intermediate formation of nitrite. Model output has been verified with pilot-scale data (Paper No. C-30, The Netherlands).

Laboratory-scale studies demonstrated that coke plant wastewaters can be treated using predenitrification-nitrification technology without pretreatment to reduce the concentrations of phenol and ammonia. Dilution of the waste is required, however, and the costs are greater than those required for biological treatment following pretreatment (Paper No. C-34, Italy).

Biological Phosphorus Removal

The addition of an anaerobic stage, exclusive of both dissolved oxygen and oxidized nitrogen, to an activated sludge process is not enough to cause enhanced phosphorus removal. Activated sludges capable of enhanced biological phosphorus removal, and those that are not, are both able to remove large amounts of BOD in an anaerobic unit of an anaerobic-aerobic sequenced system, with equivalent synthesis of poly-B-hydroxybutyrate (PHB) and similar ATP changes (Paper No. C-6, Japan).

Twelve-hour anaerobic detention times in aerobic-anoxic-anaerobic sequenced systems accomplish substantially more enhanced phosphorus removal than six-hour anaerobic detention times, but longer times provide no significant improvement in removal. Longer anaerobic detention times are also capable of overcoming the disruptive effects of nitrates recycled with the return sludge to the anaerobic unit (Paper No. C-7, South Africa).

Although polyphosphates of both low and high molecular weight are accumulated in the sludge of an anaerobic-anoxic process, low molecular fractions are mostly responsible for the release and uptake of phosphorus (Paper No. C-8, Japan).

Chemical Phosphorus Removal

Deterministic models for prediction of sludge production during chemical removal of phosphorus should consider crystalline water that will accompany the metal-phosphorus precipitates (Paper No. C-9, The Netherlands).

Phosphate sludge production is influenced by the metal ion (namely Fe or Al) to P (phosphorus) ratio and only slightly affected by pH (as long as the pH range remains between 6.5 and 7.5). Addition of ferric chloride produces 1.2 times more sludge than the use of alum. The reaction product has been identified as $AlPO_4 \cdot 2H_2O$ and $Al(OH)_3$ (Paper No. C-9, Japan).

Pilot plant tests in an upflow fixed-bed reactor (50 m^3/d over 180 days) demonstrated that phosphates can be significantly removed by seeding with granular phosphate rock. Operational variables are concentrations of calcium and phosphorus and pH. Crystal seeds are applied in the metastable zone with respect to the solubility of a crystalline calcium phosphate rock (Paper No. C-10, Japan). A fluidized bed, packed with granular calcium phosphate rocks, can also be used to remove phosphate from wastewater by the crystallization of calcium phosphates. The process produces no sludge but a small amount of waterfree pellets (calcium in phosphate form) (Paper No. C-11, The Netherlands).

Physical-Chemical Treatment

An anion exchange resin has been used to remove iron cyanide from both synthetic and actual gold mill effluents. The ion exchange capacity of the resin is 50-80% of that with synthetic solution due to interference from copper and zinc cyanides. Resin regeneration is carried out with 15% NaCl solution (Paper No. C-26, Canada).

Reverse osmosis, ultrafiltration, automatic deionization and activated carbon filtration have been used to produce ultrapure rinse waters for the electronic manufacturing industries. Water reuse is made possible through this sequence of purification process (Paper No. C-27, U.S.A.).

Sand-packed fluidized beds removed radium from uranium mining tailings by coprecipitation as $(Ba, Rd)SO_4$. Radium-226 removal exceeded 90% over a contact time of 20 s (Paper No. C-28, Canada).

A variety of factors were reported to influence the adsorption of metal ions on aluminum oxide in the presence of complex-forming ligands. Ionic strength, pH, temperature, the presence of competing cations, and the nature of the central metal ion all affect the adsorption process. The adsorption behavior of nitrilotriacetic acid (NTA) complexes of Cu(II), Zn(II), Cd(II), and Ni(II) on aluminum oxide were found to be similar, although Cu(II) binds NTA much more strongly than the other metals and also adsorbs more extensively. The adsorption sequence, Cu > Zn > Cd > Pb and Ni, was found to correspond directly to the central ion electronegativity; i.e., the least electronegative metal was the most adsorbable (Paper No. C-84, U.S.A.).

An infrared conveyor-belt furnace providing quantitative residence time, temperature and furnace atmosphere control capability was reported to be effective for regeneration of spent activated carbon. Rapid heat-up and cool-down properties facilitated intermittent operating schedules, but proper conveyor-belt tracking required special attention. The micro-, meso- and macropore volume distributions of an activated carbon were found to vary as a function of regeneration temperature and residence time and to be both non-linear and frequently non-monotonic factors of crucial importance for optimizing the process. Temperature levels in excess of 850°C during the regeneration of carbon were found to cause excessive meso- and macropore enlargement and to diminish the extent of micropore restoration. It was found impossible to effectively regenerate spent carbon at 900 to 950°C, even using very short residence times. At 950°C and residence times of 30 min or more, the mechanical strength of the carbon was found to be severely impaired (Paper No. C-85, South Africa).

A laboratory-scale experimental program using phenol as a substrate was conducted to evaluate the significance of enhanced bioactivity, bioregeneration, desorption, and metabolic end product adsorption in a combined activated sludge and powdered activated carbon (PAC) system. Radiotracer methodology and a desorption-extraction procedure that measures adsorbed phenol were used to discriminate between the various mechanisms. It was reported that PAC addition to activated sludge systems treating phenol did not enhance the rate or extent of biodegradation of the phenol; that bioregeneration occurred and was essentially complete for the phenol substrate; that mass transfer through a biofilm at the carbon surface had a significant effect on the rate of substrate removal by adsorption, and that the controlling mechanism for bioregeneration was desorption rather than direct bacterial or enzymatic attack (Paper No. C-86, U.S.A.).

The application of ozone prior to granular activated carbon treatment of a drinking water supply resulted in a final water quality with generally lower organic concentration measured as TOC, UV-extinction (254 nm) or permanganate-demand. In terms of a TOC reduction, ozone-enhanced GAC treatment resulted in an increase in filter service time of about 60% to 65%.

An ozone dosage higher than 2 mg/L showed no additional effect (Paper No. C-87, Belgium).

Ozonation prior to activated carbon treatment caused a significant increase of AOC (assimilable organic carbon) in the activated carbon effluent. Under equal operating conditions, GAC treatment of non-ozonated water yielded the lowest effluent AOC values (Paper No. C-87, Belgium).

The ozonation of aqueous solutions of a series of nonyl phenol ethoxylates, dinonyl phenol ethoxylate and polyethylene glycol was found to result in alterations in the molecular structure of these non-ionic surfactants and in changes in such material characteristics as foaming and complexation and in increased water solubility of oxidation products. Ozone treatment alone was not feasible for total removal of non-ionic surfactants from waste streams, but an alternative approach was to increase the bioavailability of the non-ionic surfactant compounds in water by partial ozonation to make them more amenable to subsequent biological treatment (Paper No. C-88, Israel).

Smaller ozone bubbles were shown to give both higher ozone residuals and disinfection efficiencies, but lower ozone utilization, suggesting an optimal bubble size exists in terms of process economics (Paper No. C-89, Saudi Arabia).

The duration of rapid mixing was shown to influence the effectiveness of flocculation of aluminum hydroxide flocs. An optimal mixing time of 30 to 60 s was suggested (Paper No. C-90, Belgium).

Continuous flow and turbidity measurements were used to automatically control the dose of iron salts in a wastewater treatment plant (Paper No. C-91, France).

A multilayer adsorption isotherm was shown to describe the removal of organics by precipitates formed from lime addition (Paper No. C-92, Poland).

Ferrous sulfate addition and filtration were used to remove hexavalent chromium from a contaminated ground water. A high rate of filtration was used to oxidize excess ferrous ion without reoxidizing the trivalent chromium formed (Paper No. C-93, France).

Disinfection and Virology

Beneficial results were presented from a study examining the disinfection of a bromide-rich drinking water supply with staggered application of chlorine dioxide and chlorine (Paper No. C-50, Israel).

Degradation and disinfection of wastewater using UV radiation from natural sunlight were described. Azo dyes were used as model compounds. The treated effluent could be used for agricultural irrigation (Paper No. C-51, Israel).

Hepatitis A virus (HAV) in tap water and sewage effluent was found to be more resistant to combined forms of chlorine than were most other enteric viruses and widely used indicator bacteria (Paper No. C-54, South Africa).

Laboratory studies on MS2 bacteriophage survival in ground water showed that temperature was the most important water quality parameter influencing virus survival with increased virus survival at lower temperatures (Paper No. C-56, U.S.A.).

When digested sludges were applied to land, some viruses remained viable in the sludge, surface-lying water and soil for at least four to six weeks, especially during the colder months (Poster No. V-13, United Kingdom).

In another study, some viruses in sludges applied to land remained viable for 21 but not 22 weeks, and in the ground water under the application site, they remained viable for at least 11 weeks. Hepatitis A virus was found to be extremely resistant to heat with complete inactivation of six logs of virus achieved in 60 min at 70°C but not at lower temperatures. Complete inactivation of HAV by formaldehyde was achieved at a concentration of 0.35% in 72 h, but at lower concentrations, some HAV persisted (Poster No. V-17, Federal Republic of Germany).

A new system capable of detecting F-specific coliphages in water and wastewater by the use of genetically constructed strains of _Salmonella typhimurium_ was developed. The detection of F-specific coliphages may be a suitable indicator for the virological quality of water (Paper No. C-53, The Netherlands).

Microporous filter methods for virus concentration from water were adversely affected by high concentrations of naturally occurring soluble organic matter in water such as humic and fulvic acids. Suspended solids in water, such as bentonite clay, also reduced virus recoveries, but to a lesser extent (Paper No. C-55, U.S.A.).

A method for detection and quantification of hepatitus A virus (HAV) was reported using concentration by electropostive and electronegative micorporous adsorbent filters, elution, and quantification by a radioimmunofocus assay in African green monkey kidney cell cultrues. The presence of HAV was further confirmed by experimental infection of chimpanzees. Electropositive microporous filters were found to be effective for concentrating a number of viruses, including polioviruses, reovirus, rotavirus and coliphages, from tap water (Poster No. V-8, U.S.A.).

Poliovirus was found to be most sensitive to chlorination close to its isoelectric point, pH 6.5 (Poster No. V-1, United Kingdom).

Complete virus removal was reported in a drinking water treatment plant with a capacity of 300,000 m^3/d treating river water containing counts between 10 and 146 PFU/1,000L. Within detection limits, virus removal was complete after preozonation (0.7 mg/L), storage, coagulation, flocculation, settling, sand filtration, and secondary ozonation (2.0 mg/L) (Poster No. V-11, France).

Active transport of coxsakievirus B3 was shown to be slightly greater than adenovirus-1 in an unsaturated, aerobic sandy soil column at 4 to 7°C with percolation rates typical of Denmark, while coxsackievirus B3 was shown to have significantly greater active transport in clay versus sandy soil columns under saturated, anaerobic condition at 4 to 7°C. Differences in viral transport were partially attributed to differences in the pore size distributions of the two soil types (Poster No. V-9, Denmark).

The removal efficiency of poliovirus-1 was studied in batch activated sludge experiments. For various organic loadings, it was found that to achieve more than 99% viral removal mixed liquor suspended solids levels of greater than 800 mg/L were required (Poster No. V-12, Japan).

A unique risk assessment strategy for determining risk levels of both viral infection (hepatitus) and cancer from trihalomethanes as a function of chlorination levels was presented. An example assessment is made using published dose response data and _E. coli_ levels from a drinking water source, Lake Biwa, Japan. Results indicated that risk of viral infection is greater than potential cancer risks, however, limited historical data makes the accuracy of these statistical results less reliable (Poster No. V-14, Japan).

Inactivation of coliphages was found to be more efficient in a facultative lagoon than in a maturation pond (Poster No. V-6, Japan).

All 284 samples at 265 locations of potable water entering distribution systems of the Seven Trent Water Authority were found free of cytopathic enteroviruses during the period of 1980 to 1983 (Poster No. V-5, United Kingdom).

Land Treatment of Waste and Wastewater

Due to a series of historical events, a situation developed in Jerusalem which allowed for a retrospective study which demonstrated a relationship beween use of raw sewage for crop irrigation and _Ascaris_ diarrhea in the population (Paper No. C-35, Israel).

Artificial wetlands were shown capable of treating primary effluents to secondary treatment levels of BOD and suspended solids. When blends of primary and secondary were used a high degree of nitrogen removal was also achieved (Paper No. C-36, U.S.A.).

Peracetic acid was demonstrated to be highly effective against tapeworm eggs and _Salmonella_ in raw sludges during land application. No toxic by-products were produced and the sludge could be treated during land application (Paper No. C-37, United Kingdom).

Determination of the mean thickness of hydrocarbons at an aquifer interface after a surface spill was expressed as a function of thickness of the oil layer in an observation well and the potential of the oil (Paper No. C-38, Switzerland).

Use of specially designed unsaturated attenuation zones underlying domestic waste landfills appear effective in reducing pollutant concentrations before the saturated zone is reached, but longer-term monitoring studies are underway to determine effects over several years (Paper No. C-39, United Kingdom).

Sludge Treatment and Disposal

A procedure for using sludge volume index (SVI) in the design and operation of secondary clarifiers has been developed and applied. The approach uses empirical relationships between SVI and solids flux theory (Paper No. C-40, South Africa).

Sludge dewaterability and polymer requirements may be related to the lipid, carbohydrate, and protein content of sludges (Paper No. C-41, U.S.A.).

Low temperature thermal pretreatment can enhance anaerobic digestion of waste sludges for which the economics need assessment (Paper No. C-43, Japan).

Reduction in metals in sludges can be achieved by biological oxidation using Thiobacillus ferroxidous. Metals are solubilized, resulting in a high concentration of metals in the supernatant. Significant reductions in cadmium, copper, nickel and zinc were observed without reducing organic or nutrient content (Paper No. C-47, Canada).

Zimpro heat-treated sludge was easy to transport, contained no pathogens and produced no odors. The sludge contained sufficient amounts of nitrogen, potassium and phosphorus to have fertilizer value. However, the nitrogen was found to enter the soil slowly (Paper No. C-49, South Africa).

Sequential extraction of activated sludge with NH_4OH and EDTA solutions leads to the isolation of the floc-forming substances. Low molecular weight substances, except metallic ions, are found to cause flocculation even under acidic conditions. There is probably no single substance in activated sludge serving as floc-forming agent (Paper No. C-42, Japan).

Aluminum hydroxide in dewatered sludges from aluminum-anodizing plants can be successfully extracted with sulfuric acid to produce liquid alum. The fixed solids content of the aluminum-anodizing sludge must be approximately 16 to 17% to allow the production of commercial-strength liquid alum (Paper No. C-44, U.S.A.).

Ionizing radiation (Co^{60}) and a linear microwave electron accelerator have been used to treat activated and digested sludges. Irradiation treatment improves the thickening capacity but increases polymer demand pre-dewatering conditioning. The irradiation at

3 kJ/kg decreases the concentration of Salmonella senf. by at least six orders of magnitude (Paper No. C-45, Czechoslovakia).

A sequential extraction procedure was used to extract "exchangeable" metals into the "adsorbed," "organic," "carbonate" and "sulfide" fractions (Paper No. C-48, United Kingdom).

Anaerobic Treatment

Coal gasification wastewater is treatable anaerobically at a dilution of 6% by volume. Inhibition of methane production was observed at a wastewater dilution of 8%; however, phenol, p-cresol and m-cresol were completely removed. Inhibition was associated with an ether extractable fraction of the wastewater (Paper No. C-12, Canada).

Microbiological analyses of the thermophilic anaerobic liquor treating a palm-oil wastewater indicated a sulfate-reducing bacterial population of 10-100/mL at 50°C. This population is approximately 1,000 times less than that reported for mesophilic conditions. The sulfate-reducing bacterial population decreased even more at 55°C (Paper No. C-13, Malaysia).

Fixed bed anaerobic reactors are more efficient in converting pectin wastewater to methane, while stirred reactors are more efficient for acidification and/or hydrolysis at high organic loadings and relatively short hydraulic detentions times (Poster No. P-8, Federal Republic of Germany).

Use of Mathematical Models

A model was presented using combinatorial suboptimal routines for optimizing the total design and operation of liquid and sludge flows in a wastewater treatment plant. The results indicated gaps in theoretical bases or empirical operational data necessary for model development (Paper No. C-52, Portugal, U.S.A.).

Water quality models have been modified and enhanced for application to the transport and fate of chemicals and hazardous wastes (Poster No. P-15, U.S.A.).

A comprehensive model for the prediction of large water resource projects was presented and was used to used to predict the water quality of a new lake which was to be affected by pollutants from agricultural sources (Poster Nos. P-16, P-17, and P-18, The Netherlands).

Combination of a two-dimensional hydrodynamic model with a dissolved oxygen prediction model provided the basis for analysis of dissolved oxygen conditions in the Test estuary. It was shown that water quality models developed for use in complex ecological systems must have accurate biological modeling components to provide a foundation for any predictions made. (Paper No. C-62, United Kingdom).

Modeling of non-conventional water quality parameters such as phenol, cyanide, and oil and grease can be handled kinetically in the same manner as conventional parameters in all of the degradation processes such as volatilization, adsorption, hydrolysis, microbial degradation. Water quality models have particular utility in organizing many variables and much data into an effective computational effort. Based upon the model, the effects of newly contemplated conditions can be projected (Paper No. C-79, Jordan, U.S.A.).

A large amount of data is necessary to calibrate and validate a water quality model. The effort required in virtually any water quality modeling effort was shown to be major (Paper No. C-79, Jordan, U.S.A.; Paper No. C-80, Denmark; Paper No. C-81, U.S.A., Korea).

Each of the many coefficients comprising a water quality model requires empirical validation. Evaluation of these coefficients is inherently uncertain. The variations can range from ~ 50% to several hundred percent. The idea of uncertainty should be addressed in any modeling efforts (Paper No. C-81, U.S.A., Korea)

Eutrophication

Flushing lakes using water with low nutrient content was demonstrated as a useful lake management tool. Flushing reduced turbidity and disrupted seasonal cycles of nutrient release and algal growth (Paper No. C-63, The Netherlands).

Control of external phosphorus sources without altering sediment phosphorus levels reduces the effectiveness of remedial lake management techniques (Paper No. C-63, The Netherlands).

Dosing the source of a major lake basin with iron sulfate was effective in reducing phosphorus concentration and curbing algae growth. The chemical dosing was effective in protecting the basin as a water supply source (Paper No. C-64, The Netherlands).

Hyacinth Treatment, Algal Harvesting, and Duckweed Treatment

Treatment of palm oil and natural rubber processing wastes with water hyacinth showed that a lagoon at 60-cm depth gave better results than at a depth of 120 cm. The water hyacinth grew with an influent BOD of 1400 mg/L and were effective in upgrading the lagoon effluent (Paper No. C-65, Malysia).

If an algae reactor hydraulic retention time is reduced, fast growing algae will remain and slow growers will be washed out. If a cross flow screen is added, there will be a washout of most organisms not retained by the screen and a single type of organism will be left which can be removed by the screen. This was shown with four innoculums and ending up with the same single organism. Increasing the screen size to 200 µm from 80 µm eliminated the clogging problem. The algae harvested at about 8% solids and could be manually dewatered to 20% solids (Paper No. C-66, South Africa.

Duckweed growth rate is similar to corn, and available ammonia nitrogen goes directly to plant protein. The dry yield is an inverse function of the influent ammonia while the protein content is a function of the influent ammonia. The water losses by evaporation was less with duckweed than with a free surface lagoon. Duckweed can be used as a fish food without drying (Paper No. C-67, Israel).

Resuspension and Sedimentation of Particulates

Laboratory results were effectively simulated by a model which described the sediment interface yield coefficient as a function of the integral of the sediment velocity gradient with respect to time (Paper No. C-74, Japan).

A model of the net effect of resuspension and settling was used to simulate the suspended solids concentration in a shallow lake. Four resuspension models were evaluated and best results were obtained with the use of the Somlyody model, an expression for flow-induced resuspension. Gradients in suspended solids were measured across a lake, but no uniform relationship between wind and suspended solids was found to be applicable to all times and locations (Paper No. C-75, The Netherlands).

When subjected to a cyclical steady-state approximation of the tidal cycle, estuarine suspended solids were influenced by three mechanisms: erosion, dispersed particle settling, and flocculent settling (Paper No. C-76, Japan).

Benthal Deposits

A model of the benthal stabilization of organic carbon and nitrogen was developed and validated for rapidly consolidating, heavily organic deposits. Simulation results indicated that bental stabilization capacity was much higher than the organic loading rates currently used in the design of wastewater treatment lagoons (Paper No. C-77, U.S.A.).

The fluxes of calcium and phosphate from benthal deposits was proposed to be controlled by desorption at or just below the interface, rather than by diffusion. Thus, concentrations in the overlying water were more important than those in the interstitial water when determining transport coefficients (Paper No. C-78, The Netherlands).

Based on a four-year monitoring program, the sediment-water exchange of phosphate in a shallow lake was modeled as a function of the temperature and phosphate concentration of the overlying water (Poster No. P-40, The Netherlands).

Analysis of Water and Wastewater

A computer model has been developed to compute the concentrations of the major ions from conductivity and pH data. An advantage is that the model calculates all ions of interest, whereas this is not possible with the traditional regression equations; the disadvantage is that it is complex compared to the latter (Paper No. C-69, Federal Republic of Germany).

Enzymatic microcalorimetry has been used to measure the levels (but not the concentrations) of organophosphorus and carbamate insecticides. This technique still needs development before it will be useful (Paper No. C-71, South Africa).

A computer-based model consisting of a hydraulic simulation routine provides useful information for habitat analysis. Habitat analysis can be used in addition to traditional water quality analysis for managing water resources. Species and life stage specific habitat data and a weighted usable area for a specified discharge value are the primary outputs of this model (Paper No. C-73, U.S.A.).

Transport and Processes in Sewers

Development and full-scale operation of weirs for the automatic control of storm water overflows were discussed (Paper No. C-101, Federal Republic of Germany). These weirs have proven to reduce overflow occurrences and surface water pollution and to be reliable in operation.

The processes which occur in combined sewers under substantial flow variation in dry and wet periods include sedimentation, mineralization, and resuspension of sludge (Paper No. C-102, The Netherlands).

Biomonitoring

Artificial substrate samplers have been shown to be valuable macroinvertebrate collection devices (Paper Nos. 2* and 3*, United Kingdom and Belgium).

Biotic indices are valuable tools for biological condition assessment, but information is lost in index calculation (Paper Nos. 2*, 3*, and C-72, United Kingdom, Belgium, and The Netherlands).

Conservation issues must be dealt with in planning biological assessments. The opportunities for savings realized if collection activities are optimized can be applied to other aspects of biological monitoring or conservation (Paper Nos. 1*, 4*, and 21*, U.S.A., United Kingdom and U.S.A.).

Classification of stream conditions is possible using physical, chemical and biological information (Paper No. 5*, United Kingdom).

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*Note: Paper numbers refer to those for the Seminar on Freshwater Biological Monitoring, September 12-15, 1984, Cardiff, United Kingdom.

Invertebrate drift, chlorophyl _a_ concentrations, and heavy metal concentrations in _Lemna_ were demonstrated as valuable biomonitors which supplemented or replaced chemical monitoring (Paper Nos. 6*, 7*, and 17*, South Africa, Finland, and Japan).

Fish tissue analysis can be used to identify causes of fish kills and assist in source location (Paper No. 8*, Belgium).

Monitoring of fish and invertebrate bioelectric signals is useful in industrial site monitoring and monitoring non-point pollution at remote sites (Paper Nos. 10* and 11*, South Africa and U.S.A.).

Toxicity testing using large groups of organisms, (Paper Nos. 12 and 13, United Kingdom and Australia) or using experimental ponds provide insight into toxic substance effects and mechanisms of effect (Paper Nos. 12, 13, and 14, United Kingdom, Australia and United Kingdom).

Issues of adaption as well as acclimation must be evaluated in any organisms exposed to chronic pollution which have relatively short life cycles (Paper No. 16*, United Kingdom).

Algal assays and analysis of mutagenic responses in bacteria were shown to be valuable biomonitors (Paper Nos. 18*, 19* and 20*, Norway, United Kingdom, and Japan).

If biomonitoring results are to be used in regulatory programs, issues of data quality and characteristics must be identified and met; biological monitoring must provide data which will determine actual consequences of pollutant discharge (Paper No. 21*, U.S.A.).

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B. Developments Outside of Formal Sessions

It is universally understood that many of the benefits of Conferences such as this are realized outside the formal session chambers. This is particularly true at international conferences. The purpose of this section is therefore to summarize the more informal aspects of the technical developments with emphasis on those topics which best relate to U.S.A. water pollution research. These comments are identified with the individual participants and do not necessarily reflect the view of the United States of America National Committee (USANC) or of the United States Environmental Protection Agency.

Biological Nitrogen Removal

Knowledge concerning single-sludge carbon oxidation-nitrification-denitrification systems appears to be more advanced in Europe, Japan, and South Africa than in the U.S.A. Whereas engineers in the U.S.A. have tended to view the system simply as a way to achieve denitrification, colleagues in other countries see it as a way to achieve well treated and nitrified effluents with lower energy and chemical costs. Even if denitrification is not required, they view it as a means of recovering energy and alkalinity expended while achieving nitrogen oxidation (Grady).

Compared to the U.S.A. and Canada, there appears to be less concern among researchers in other countries over the fate of trace concentrations of toxic organic chemicals present in wastewaters (Grady).

Canadian researchers desire to establish simple and effective techniques for estimating how effective a given biological process is likely to be in removing toxic organic chemicals present in low concentration (Grady).

European and South African emphasis on predenitrification treatment for nitrate reduction and energy recovery reinforced Randall's (U.S.A.) recent statements about complimentary improvements in the cost-effectiveness of nitrification systems (Alleman).

Biological Phosphorus Removal

A post-conference seminar on "Enhanced Biological Phosphorus Removal from Wastewater" was held in Paris, France following the Conference on September 24-25,

1984. Papers containing extensive evidence of enhanced biological phosphorus removal were presented and mechanisms of removal were discussed including reports of both pilot-scale and full-scale experimentations. The experiments at Kalowna, British Columbia, which were presented by Oldham (Canada) are of particular interest to researchers in the U.S.A. because they have demonstrated that enhanced biological phosphorus removal can be accomplished while treating low strength wastewaters typical of North America. This is accomplished by permitting partial fermentation of the settled primary sludge and then the addition of the fermentation products to the anaerobic reactor of the phosphorus-removing activated sludge system. Details on how to accomplish this have been presented by Barnard (South Africa). Basically, it involves the addition of a thickener for the primary sludge and recycle from the thickener underflow to the primary clarifier to establish a sludge blanket in the clarifier (Randall).

The feasibility of using a circular flow pattern in modified activated tanks to accomplish both biological nitrogen and phosphorus removals was demonstrated by a full-scale system near London (Best et al., England). An unrelated paper proposed that a system of this type would be more energy efficient and, therefore more economical than a conventional aerobic activated sludge system (Randall).

An investigation of the biologically-induced chemical precipitation of phosphorus that can occur in an anaerobic-aerobic sequenced activated sludge system was presented by Arvin and Kristenson (Denmark). It appears that with certain wastewaters, these mechanisms can be used to obtain high levels of phosphorus removal without the addition of chemicals (Randall).

Many delegates noted that the U.S. E.P.A. had changed their earlier philosophy considering the chemical phosphorus precipitation mechanism. Many delegates, particularly those form South Africa, indicated that the chemical precipitation mechanism has been thoroughly examined and will soon be disregarded in biological phosphorus removal systems. More objective comments from people interested in this topic stressed the point that much more research must be carried out on the design and oeprational conditions affecting the Bardenpho process, the A/O process, and the Phostrip process. The first two processes are often hampered by sludges which do not settle easily. The last process may operate at less than expected efficiency.

Microbial species must be identified which can be used for these alternate aerobic and anaerobic conditions. Optimum design and operation conditions must be determined (Carberry).

Anaerobic Treatment

A visit to the environmental engineering research laboratories of Lijklema at the University of Wageningen, The Netherlands, provided an opportunity to discuss projects on the upflow anaerobic sludge bed (UASB) process. The success of this process depends on forming an active biomass in the form of sludge granules which possess excellent settling properties and therefore allow a high rate of treatment. The UASB has potential for treatment of high strength wastes; about 25 are currently in operation. The research problem being addressed at Wageningen is start-up of the USAB--type and quantity of seed sludge and composition and strength of wastewater. Guidelines for process engineering are provided. This treatment process may have potential in developing countries as well where simple technology is needed (DiGiano).

The IAWPRC Committee on Design and Operation of Large Wastewater Treatment Plants has been expanded and is directing an effort to develop a worldwide data base to assist designers and operators. This type of function would provide an invaluable assistance to scientists and engineers worldwide (Eckenfelder).

Considerable attention is being focused worldwide on improving the performance of anaerobic processes treating soluble industrial wastewaters, municipal sewage and municipal and industrial sludges. Problems encountered with excessive foaming in stirred reactors at high organic loading rates have limited the development of the full potential of the anaerobic contact process to treat a variety of industrial wastewaters and sludges. Factors causing foaming, composition of the foam and methods of effective control need to be understood more fully through research efforts in the laboratory and in field installations in order to maximize the energy production from the treatment of wastes and the recovery and reuse of this energy in the form of heat or as mechanical or electrical power (Malina).

More operating experience with the upflow sludge blanket reactors continue to point to advantages of this sytem over stirred reactors and packed-bed systems used for anaerobic wastewater treatment. Recently reported results indicate that filamentous organisms develop in the sludge blanket and pellets are rarely seen. The filamentous sludge remains in the sludge blanket, and there is very little carryover of solids in the effluent. The performance of the system with the filamentous organisms is similar to that reported for sludge blankets with primarily pelletized sludge. Additional information and operating data on the anaerobic sludge blanket reactors, either as a single unit or as a series of compartments is required for the development of design relationships and operating parameters. The effects of powdered activated carbon on the performance of the anaerobic sludge blanket reactors also must be evaluated especially as more emphasis is placed on the application of anaerobic processes for the treatment of complex industrial wastewaters which contain potentially toxic or inhibitory constituents, e.g., coal gasification wastewaters. More and more emphasis will be placed on applications of the anaerobic sludge blanket reactor, since accumulation of biomass in anaerobic packed-bed reactors causes problem with plugging and the energy required in fluidized bed systems is higher than that used in the upflow sludge blanket reactors (Malina).

Rotating Biological Contactors

Harremoes (Denmark) broached the topic of forming a working group of biofilm kinetics. Such a group should benefit the U.S.A. and deserves strong U.S.A. support. Discussions reveal that the state-of-the-art in biofilm kinetics is rapidly advancing, but that disagreements about fundamental issues are apparent. Therefore, a working group would most beneficially codify terminology and coordinate research, but a generally agreed upon kinetic approach seems a distant goal (Rittman).

Considerable discussion was devoted to rotating biological contactors; however, the presented papers and ensuing discussion focused on mathematical models and verification of these models with design relationships using kinetic coefficients and design parameters which were not relevant to any particular municipal or industrial wastewater. It appears that much of the current research dealing with rotating biological contactors is tracking the course of early work on the activated sludge process through use of using relatively simple substrates such as glucose and methanol. Much of the theoretical work on the transfer of substrate and oxygen into fixed films has been developed and published in the last ten to twenty years.

However, the new models which are being developed for the rotating biological contactors seem to overlook much of these earlier contributions. Research dealing with rotating biological contactors needs to focus on design relationships for a variety of municipal and industrial wastewaters such as hydraulic detention time, parallel operation compared to series operation, control of slime thickness to reduce massive sloughing of the entire slime mass, the effects of suspended biological solids on overall performance, the need for auxiliary aeration, etc. The development of a better understanding of the transfer mechanisms may be desirable; however, the development of effective design relationships is more important if this process is to gain widespread applicability (Malina).

Physical-Chemical Treatment

There continues to be a high degree of interest in the use of ozone to treat highly colored, toxic, non-biodegradable organics. Discussions were held on the applicability of ozone to treat runoff waters from asphalt surfaces. The concern here was pollution of high-quality ground waters in mountain spa areas. Better utilization of ozone in reactors together with various catalysts, such as ultraviolet light and ultrasound, likewise, were discussed. Because of high energy costs associated with ozone production, catalyst use is being considered in an attempt to reduce operational costs (King, Sierka).

Pretreatment systems to reduce fouling of reverse osmosis membranes was a topic considered by several conference participants. Once again, ozone received the major amount of attention as an appropriate pretreatment method (King, Sierka).

The experience of Keirsse _et al_. (Belgium) in the production of activated carbons from waste materials has little significance (Paper No. 7, post-conference seminar on Advanced Treatment Technologies for Removal and Disposal of Micropollutants). Raw material costs are minor in the overall scheme of activated carbon production. From their data, the surface chemistry of activated carbon produced from sawmill residues is complex. Further research into the nonlinear responses obtained would enhance our understanding of this type of adsorption and lead to better employment of activated carbon (King, Sierka).

Virology

In a study in the Federal Republic of Germany, mesophilic sludge digestion followed by pasteurization was capable of completely inactivating three enteric viruses, including a parvovirus. Some parvoviruses survived sludge digestion alone (i.e., without pasteurization) (Gerba).

Rotaviruses, a waterborne cause of gastroenteritis, have been isolated from the Ottawa River which is used for both drinking water and recreational purposes. Human rotavirus is more resistant of inactivation by chlorine than poliovirus (Gerba).

Slade (United Kingdom) reported the isolation of viruses in well water surviving 1 mg/L of free chlorine after a contact time of 15 minutes. Viruses were isolated in the untreated water in the absence of coliform bacteria. The Thames Water Authority tests from 800-1,500 water samples annually for viruses (Gerba).

Morris (United Kingdom) reported that BGM cells gave the best recovery for entroviruses from water of all cell lines tested (Gerba).

Payment (Canada) reported the isolation of enteroviruses in drinking water after chemical flocculation, sand filtration and chlorination. The finished water containing viruses exceeded coliform and turbidity standards used in the United States (Gerba).

One of the highlight activities outside of the formal sesions was technical visits to the Keuringsinstituut voor Waterleidingartikelen (KIWA) in Rijswijk and the Rijksinstituut voor Volksgezondheid en Milieuhygiene (RIVM) in Bilthoven. At the KIWA, van Olphen and colleagues demonstrated and described their field equipment for concentrating viruses from water by adsorption to and elution from electronegative filters and described their field sampling programs for viruses in water. Their equipment and methods are patterned after similar equiment and methods developed in the U.S.A. Their equipment is quite compact and portable and is semi-automated with small metering pumps to deliver chemicals for conditioning of the water (pH adjustment, salt addition and dechlorination) prior to passage through adsorbent filters. Viruses in filter eluates are further concentrated by ultrafiltration in stirred cells using 1000 molecular weight cut-off membranes. In their surveys for viruses in finished drinking waters from both surface and ground sources, no viruses were found in sample volumes of 100 to 500 L. They also investigated reductions of indigenous enteric viruses during long-term storage of water in reservoirs and found extensive virus reductions. These findings add important new information to the rather limited existing literature on virus reductions during water storage in reservoirs. Field studies are to be conducted on virus removal by dune filtration of raw surface waters. These latter studies also should provide valuable new information, although not especially relevant to U.S.A. water treatment practices. The extensive water treatment, including long-term storage and dune filtration, given surface waters in the Netherlands may explain why enteric viruses were not found in drinking water in their surveys (Sobsey).

Kapsenberg (The Netherlands) and colleagues of the RIVM demonstrated and described their immunofluorescence and genomic analysis methods by electrophoresis for rapid identification of rotaviruses and enteral adenovirus types 40 and 41 in feces. Also demonstrated and described were serological methods to identify enterovirus isolates using enterovirus antiserum typing pools produced at the RIVM. These pools would be valuable reagents for U.S.A. and other workers because U.S.A. enterovirus antiserum typing pools produced by the National Institutes of Health are completely exhausted. The RIVM was willing to sell sets of these pools to scientists who wanted them for about $60.00. Until new enterovirus antiserum pools are produced in the U.S.A., the pools from the RIVM may be the only ones readily available at reasonable cost. The RIVM has a sophisticated capability for the isolation and identification of viruses in clinical specimens and environmental samples (Sobsey).

Van Wezel (The Netherlands) described the sophisticated facilities of RIVM for large-scale cultivation of mammalian cells from primary tissues and for producing viral vaccines and other biological products. This facility is recognized worldwide as one of the most technically advanced operations of its kind, and van Wezel and colleagues have done pioneering work on methods for large-scale cultivation of mammalian cells and the production of vaccine viruses and other biologicals (Sobsey).

Havelaar (The Netherlands) and colleagues of the RIVM demonstrated and further described their work on the development and evaluation of F-specific coliphage hosts and the use of F-specific phages as indicators of water quality. Havelaar (The Netherlands) offered to make his new coliphage hosts available to visiting scientists. The development and availability of this new coliphage host offers considerable promise for a better coliphage indicator system for determining the virological quality of water and the effectiveness of treatment processes in reducing virus levels (Sobsey).

Another development outside of the formal sessions was an informal presentation to the seminar participants by Gerba from the University of Arizona (U.S.A.) on current risk assessment efforts within the U.S. E.P.A. Office of Drinking Water. These assessments, in which Gerba (U.S.A.) participated this past summer, are being done as part of the overall effort to develop revised microbiological regulations for U.S.A. drinking water supplies. Gerba (U.S.A.) explained that Federal regulators need options for decisions on how to control virus transmission via drinking water. Part of the risk assessment effort includes an analysis of the proportion of people within a population that are likely to become ill with viral disease when their drinking water contains different levels of viruses. An important item being considered in the regulations is the circumstances under which viral monitoring of drinking water supplies would be required and the requirements of a viral monitoring program. Virus monitoring may be required if water utilities want waivers or variances from the treatment requirements being considered in the revised regulations now under development (Sobsey).

An important topic of interest and discussion was the reports of virus isolations from finished drinking water supplies. An investigator from the United Kingdom reported finding no viruses in a drinking water survey within his water authority, but that viruses were found in subsequent studies in a large finished drinking water supply produced from chlorinated ground water. This supply was occasionally positive for coliform bacteria but usually met coliform standards. An investigator from the German Democratic Republic related virological and epidemiological studies in a town using contaminated river water as its source. This town has one of the highest rates of hepatitis A in the country and HAV antigen has been detected in the river water used as the raw source for producing drinking water. During a waterborne outbreak of gastroenteritis in the same town, enteroviruses were isolated from the town drinking water (Sobsey).

Many participants felt that the growing number of reports of viruses in finished drinking water supplies added support to their belief that further studies on viruses in drinking water are needed in order to determine more completely the occurrence of viruses in finished drinking water, the circumstances under which they occur and the means for their control. In addition, there was considerable support for the performance of carefully designed epidemiological studies to determine the health effects of having detectable levels of viruses in drinking water. The importance of funding such studies was stressed. There was considerable concern that interest in waterborne viruses was declining among other water scientists and engineers and funding sources. For example, some water virology programs in the United Kingdom may be cut back and their laboratories may soon be closed down (Sobsey).

Many participants were encouraged by recent development in the ability to cultivate and assay HAV and study its occurrence, survival and fate in water. They felt that further work in this area was essential, and it is likely that more vater virologists will begin studies on HAV in the near future. Another topic of considerable interest and discussion was the Norwalk virus and other small round gastroenteritis viruses. It was recognized that these viruses are important etiological agents of waterborne disease throughout the world, but that the present inability to cultivate and assay these viruses has hampered efforts to study their occurrence, behavior and control in drinking water and other waters. Hope was expressed for breakthroughs in the cultivation and assay of these viruses so that water virology research on them could progress (Sobsey).

There was also considerable interest in and discussion about the continued development and use of electropositive adsorbent filters for virus concentration from water. With continuing validation of these filters as being convenient and effective, they are gaining wider field use by water viologists throughout the world. A major concern, however, was their relatively high cost compared to electronegative filters, which has discouraged their use by some investigators. Despite this economic limitation, their use in field studies is likely to increase. For this reason, standardized methods for their use should be included in various manuals of methods for virus concentration from water (Sobsey).

The question of virus standards for drinking water and other waters was a topic of lively discussion, but as in the past, there was no clear consensus of opinion about such standards and the need for routine virus monitoring of waters. The recent WHO guidelines for virological quality of drinking water, which are based on source water quality and protection and treatment requirements to achieve a desired turbidity and chlorine residual, were considered adequate for the time being. However, some participants expressed the need for more definite regulations dealing with viruses in water (Sobsey).

In a meeting of the IAWPRC Water Virology Study Group, the considerable value of the Water Virology Newsletter as a source of useful scientific information and exchange was noted with enthusiasm. With the considerable success of the Amsterdam meeting, it was resolved that every effort should be made to hold another water virology seminar at the 1986 IAWPRC Conference in Rio de Janeiro (Sobsey).

Hazard Evaluation for Biological Effects

The emphasis in U.S.A. toxics control programs follows a general hazard evaluation scheme of detailed physical and chemical analysis for fate determination and tier testing for biological effects determination. The European approach is somewhat different, and in the area of biological testing, European laboratories appear to be giving a greater emphasis to ecological effects analysis (as compared with the U.S.A. emphasis on single species testing). The major difference in European hazard evaluation is a strong reliance on production controls. If a substance is considered toxic, the major control is on production rather than depending on some assessment of assimilative capacity to determine discharge limits. The major emphasis in OECD developments in the hazardous materials control area is in physical and chemical analyses, although the core testing requirements for registration of a chemical with OECD is extensive (Herricks).

Laboratories visited in Europe are conducting research with a strong ecological orientation. Emphasis appears to be on not just multispecies testing, but comprehensive ecological analyses which incorporate measures of interactions between populations and may provide additional predictive capability to early tier testing results. United States researchers should pay particular attention to European developments in ecological testing (Herricks).

In the Netherlands, lake management activities are critical to the overall land maintenance and public water supply programs. Thus, the implementation of large-scale manipulations to control water quality and biological conditions [illegible] eutrophic systems are common in The Netherlands. Lake management programs, particularly efforts in large-scale manipulation, have not received as much attention in the United States. As surface waters grow in value as water supplies, and water supplies dependent on run-of-the-river reservoirs which are subject to rapid eutrophication become more common, United States water resource managers may look to the Netherlands for proven methods of eutrophication control (Herricks).

European approaches to the assessment of stream quality have been dependent on biological surveillance approaches since the turn of the century. Because stream fauna is reasonably well characterized, the Europeans have developed a number of biotic indices for water quality assessment. Although the application of indices is still argued in European scientific circles, U.S.A. biologists can benefit from evaluations of the success and failures of biotic index applications in Europe. Of particular importance is the European development of techniques to better relate organism presence and abundance with ambient water quality measurements. At present, U.S.A. stream quality data collection efforts centered around STORET have not achieved the level of integration that is evident, at least, in the United Kingdom (Herricks).

Modeling of Environmental Systems

Comments regarding the modeling of environmental systems have stressed the importance of coordination between the researcher and the user. Two informal interviews were conducted to provide added information on this point. Somlyody (Hungary) discussed the factors which led to the development and timely use of a water quality model for management of a large Hungarian lake. First, an implementation schedule was established by government and research personnel: five years for model development, policy definition in the following year, and a mid-point review for goal adjustment during the development period. The process provided high visibility of management goals and a sequence of research-management interactions which significantly altered the initial plans of the researcher (Bryant).

Lijklema (The Netherlands) discussed the coordinating committee involved in eutrophication problems in the Netherlands. Government and research personnel establish long-term goals for model development and compatible policies for short-term remedial actions. The committee attempts to define specific study areas, coordinate separate physical and biological research needs, and monitor software development over a typical period of five to seven years. The process focuses the attention of Dutch researchers on model application. Similar research in the U.S.A. should be strengthened by formal initial goal definition and formal interim coordination with the eventual users of the model under development (Bryant).

Cost and Energy Effectiveness for Wastewater Treatment

A common thread of many of the treatment-related papers presented at the Conference, even those dealing with substantially different processes, was the need for cost and energy reduction and improvement of operating effectiveness and efficiency. There is nothing particularly new about this theme, but the emphasis seemed somewhat greater than at previous conferences. What was somewhat different, or at least more common, was that in several cases these goals were approached through the use of combined or integrated process schemes (e.g., carbon addition to biological systems, and encouragement of biological oxidation by chemical pretreatment). Based on the generally encouraging results reported in the papers discussing integrated treatment concepts, this would seem to be a fruitful area for future research (Weber).

There also seemed to be a continued interest and emphasis on the behavior of specific organic chemical pollutants (versus BOD, COD, or TOC) in treatment systems and on treatments which effectively address specific types of organic pollutants. This was particularly evident in discussions from the floor at several sessions and from extra-session information discussions (Weber).

Pollution Control Research Topics

Pollution research among some developed countries, Japan and United Kingdom particularly, seems to have great emphasis on long-term, fundamental and mechanistic investigations, rather than just providing an immediate engineering solution to a specific pollution problem. This is evidenced by the handful of fundamental papers presented at the conference by the

Japanese investigators. A seminar on recent developments and future needs in water and waste research, held in 1982 in the United Kingdom, has also called for an emphasis on fundamental research. It seems obvious that for U.S.A. pollution researchers to be competitive, simply by providing a short-term solution to practitioners, is no longer adequate, although it is felt that there would be continuing pressure from funding agencies and users for immediate solutions to the nation's urgent pollution problems (Huang).

There are research needs to identify and control water pollution problems associated with "high-tech" industries. Throughout the entire conference, the subject matter was only minimally discussed (Huang).

The control of trace and toxic chemicals and in water remains as one of the most critical pollution problems worldwide. Much research is needed to develop new and reliable analytical techniques and effective and innovative treatment processes, although significant progress has been made over the past few years, especially in the development of monitoring instrumentation (Huang).

The scope and the nature of water pollution problems and their solutions differ significantly between the developed and developing and underdeveloped countries. Researchers among the developed countries, except perhaps the Japanese and the British, appear to show little or no interest in water pollution problems associated with developing and under-developed countries. How much U.S.A. researchers should devote their research effort on this subject matter is debatable. This is an area that deserves future attention (Huang).

The development of trenchless pipe laying technology and waterless systems for sewerage disposal and the reuse of effluent and sludge are among some of the future research needs identified in the United Kingdom that are also quite relevant to U.S.A. water pollution research (Huang).

Pollution Control in Eastern Europe

In talks with the conference delegates from Eastern Europe, the following major activities were discussed: (a) series of fundamental and applied studies on zero discharge systems are being conducted, and (b) safe methods of solid and hazardous waste disposal are being developed and implemented (Khudenko).

At several large industrial complexes in the United Soviet Socialist Republic (Moscow, Tobolsk, Saravot, Pervomaysk) tertiary treated municipal wastewater and storm water are used as make-up water for cooling systems and process water supplies. The industrial water management systems are usually comprised of several interrelated water supply systems and separate wastewater systems, often including more than one industrial wastewater system. Major problems in the development of the overall water management systems are: providing the necessary reliability and flexibility; disposal of mineral solid and liquid (brine) wastes; treatment of recycled cooling water, especially, salt removal; and, environmental concerns in conjunction with air pollution by mist carried out from cooling towers. The reliability and flexibility of these systems overall is provided mainly by the use of storage, control, and emergency discharge tanks and ponds which also perform treatment functions. In addition, reserve equipment, treatment units, and necessary connections between subsystems are provided (Khudenko).

Disposal of highly soluble or leachable mineral residues and brines was found to be a more difficult problem than disposal of combustible organic sludges, vat residues, and froth or scum products. Hydrometallurgical processes are used for removal and utilization of heavy metals from the mineral residues. Electrodyalysis, ion exchange, and distillation are used for brines. In electrodialysis, alkalies and acids are recovered. The regeneration of ion exchange columns is performed by nitric acid and ammonia water. Regenerating solutions are blended and the salts composed mainly of sodium, potassium, ammonium, chloride, sulfate, and nitrate ions are crystallized and marketed as a fertilizer. Distillation is used as a volume-reduction method prior to deep well injection. Cooling water desalination is performed mainly by the use of ion exchange filters with nitric acid-ammonium water regeneration (Khudenko).

It is suspected that air pollution, especially by viruses, due to wastewater use for make-up water; chromium or other corrosion control chemicals; and organics in the recirculated water, may occur. Several cooling towers are being monitored for these pollutants. In addition, a toxicological study with a model mist and mist produced from cooling water with warm-blooded animals is being conducted (Khudenko).

The safe disposal of solid and hazardous wastes is achieved by double lining disposal sites with sand or pea gravel fill between liners and providing either vacuum or an elevated air pressure between the lining layers (Khudenko).

Industrial Trade Exhibits--Amsterdam

About 300 industrial exhibits were shown at Aquatech, a large industrial trade exhibit. These included many exhibits in the categories of pumps, pipes, instruments, equipment for wastewater treatment covering about the same spectrum of exhibits as found at a WPCF trade show. Despite the fact that most of the Aquatech exhibits were similar, and, indeed, some were the same, a number are worth recounting as examples of innovation or progress outside the United States perspective. Four of these were the use of plate settlers having horizontal instead of vertical flow; the use of activated carbon in diatomaceous earth filtration as a deposit after the precoat; the use of sand having a biological film as a fluidized biological bed reactor, and the continuing development of multi-effect flash distillation technology. The development of membrane technology was also evident, but this is similar to progress in the U.S.A. Aquatech provided an opportunity to view European commercial developments and to compare with those in the U.S.A. (Hendricks).

European Institutions--Water Pollution Control

Discussions with others and the field trip visits raised some questions concerning the various forms of institutions for water pollution control in Europe. It would be worthwhile to know more about some of them as a part of our general knowledge. For example, the Water Research Centre of the United Kingdom is a organization which provides research support for the British water industry. Funding is provided through the ten regional water authorities. But additionally, the organization's laboratories may take on funded projects and provide a worldwide consulting service. Some questions are: How does the WRC as an institution affect the vitality of university research; and Do projects abroad compete with consulting firms? A study of this institutional arrangement could be useful in terms of future policy guidance for the U.S.A. Often, far-reaching policy decisions are made without the benefit of assessing the full picture of the effects on the total research establishment. Looking at other empirical cases is a useful way to gain insight, even though the context is different (Hendricks).

Dutch institutions for water pollution control are another area of interest. The Dutch water boards have been organized since the fourteenth century, initially to control sea water intrusion, and presently they manage virtually all aspects of water within their respective jurisdictions, including control of water pollution. Although the use of licenses for pollution control dates back to the seventeenth century, evidence from field trips indicated that a comprehensive pollution control effort is recent. Indeed, the Pollution of Surface Waters Act of 1970, revised in 1982, appears to be the first national legislation for comprehensive water pollution control. This seems to be borne out by field trip visits where two major sewage treatment plants, the De Groote Lucht and the Shell Permis plant, both adjacent to the Rhine River, were completed in 1982 and 1983, respectively. This is not to imply that the Dutch have only recently started to treat their wastewaters, since about 500 municipal and 200 industrial treatment plants have been built, and, of course, the well-known Pasveer Ditch was developed in 1953 (Hendricks).

Also of interest are the roles of the Dutch universities and the research organizations. The former would include the Agricultural University of Wageningen and the Technological University of Delft, while the latter includes the TNO Research for Environmental Hygiene. Also the International Institute for Hydraulic and Environmental Engineering in Delft plays an important role in development of technologies and in training for the less developed countries. Its facilities are all that could be desired, the faculty is experienced, and its reputation is commensurate (Hendricks).

While most of us focus upon technology as a means to solve problems, the institutional arrangements are no less important. The only way to know and understand institutions is through empirical study as offered by the experiences of other countries. A comparative study of water pollution control institutions in other countries, with general dissemination of the knowledge gained, would be useful to the U.S.A. efforts (Hendricks).

Impact of Toxic Industrial Pollutants on Water Quality

Increasing concern for toxic industrial pollutants and their impact on water quality is apparent in both developed and developing countries. One report from France was concerned with municipal well water contamination by hexavalent chromium and of the development of a chromium removal system. El Gohary (Egypt) of the Egyptian National Research Centre stated during a conversation that the adverse impacts of industrial water pollution had reached such severe proportions in Egypt that the country was increasingly considering mandating source reductions through manufacturing process modifications, recycle and reuse, and prohibitions on the release of certain recoverable types of manufacturing residues and by-products. A conference on this approach, co-sponsored by ASTM, is scheduled for Alexandria in 1985 (Patterson).

Training of Operating Personnel

One of the current unanswered needs for small plants remains the development of formal education and training requirements for improving the operation of small wastewater treatment plants. Although many states and nations have operator certification programs, the training vehicles have not been perfected for providing the required knowledge uniformly (Baumann).

APPENDICES

	Description	Page
A.	Program: 12th Biennial International Conference on Water Pollution Control September 17-21, 1984....................	286
B.	Program: Seminar on Freshwater Biological Monitoring, September 12-15, 1984, Cardiff, United Kingdom............	318
	Program: Seminar on Advanced Treatment Technologies for Removal and Disposal of Micropollutants, September 24-25, 1984, Antwerp, Belgium........................	325
C.	Memorandum: "Development of Report for E.P.A. on IAWPRC Amsterdam Conference," August 1, 1984..........................	330
	Memorandum: "Assignments for Development of USANC Report on Amsterdam Conference; September 17-21, 1984," August 28, 1984..	335
	Memorandum: "Supplement to Guidelines for Preparation of Individual Reports," October 23, 1984........................	346
D.	*Assignments*: Participants in USANC Report.................................	354

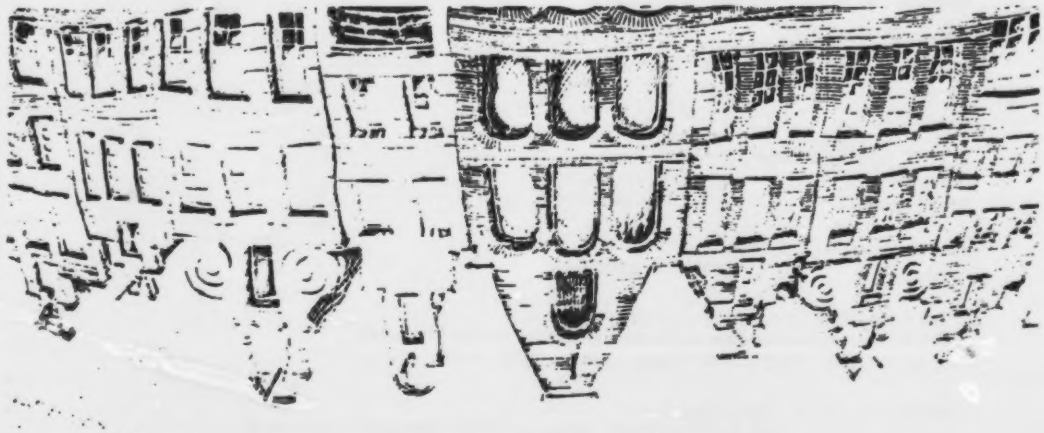
APPENDIX A

Program: 12th Biennial International Conference on Water Pollution Control, September 17-21, 1984

IAWPRC

AMSTERDAM

12th Biennial
International Conference
on Water Pollution Control
17 - 21 September 1984



1 Outline Programme

Sunday 16 September 1984

14h00-19h30	Registration at the RAI conference centre
18h00-19h30	Meet and Greet reception in the RAI

Monday 17 September 1984

08h00-17h00	Registration at the RAI conference centre
10h00-12h00	Opening Ceremony of the conference and the Aquatech exhibition in the RAI conference centre
14h00-17h30	Technical sessions
18h30-20h00	Governmental and Municipal reception in the 'Rijksmuseum' in Amsterdam

Tuesday 18 September 1984

09h00-17h30	Technical sessions

Wednesday 19 September 1984

09h00-17h30	Technical sessions
19h00-01h30	Amsterdam Night

Thursday 20 September 1984

09h00-16h30	Technical sessions
16h30-18h30	Farewell cocktail in the RAI

Friday 21 September 1984

08h30-17h30	Technical visits

- The poster presentations will be open every day
- The Aquatech Exhibition will be open from Monday to Thursday from 10h00 to 17h00 and on Friday from 10h00 to 15h00

Specialist Technical Meetings

• 20-21 September 1984	IAWPRC Study Group on Water Virology in Bilthoven
• 20 September 1984	Seminar on Pollution Management in Developing Countries in Delft.

> Conference Badges must be worn to gain entry to the technical sessions and to the social events.

2 Opening Ceremony

RAI Conference Centre on Monday 17 September 1984
from 10h00 - 12h00 in Hall 1 (Grote Zaal)

Programme

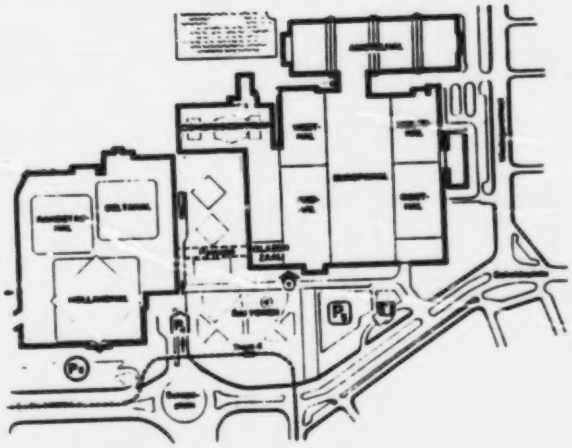
9h00 - 10h00 Reception with coffee in the area around Hall 1, near the registration desk.
10h00 - 11h00 Welcoming address: Ir. H. Ehrhardt, Conference President
Mr.J.Verweij, Chairman Aquatech Advisory Committee
Dr.Ir.W.C. Witvoet, President Netherlands Association on Wastewater Treatment and Water Pollution Control (NVA)
Prof. Dr.R.S. Engelbrecht, President IAWPRC
Opening address: His Royal Highness Prince Claus of the Netherlands.
11h00 - 12h00 Performance of the "Internationaal Folkloristisch Danstheater".
Master of Ceremonies: Mr. R.S. Johnson, Director of Industrial Presentations Europe

An invitation for the Opening Ceremony is included in your conference bag.
The performance of the "Internationaal Folkloristisch Danstheater" is sponsored by the following ONRI Consulting Firms, members of FIDIC:

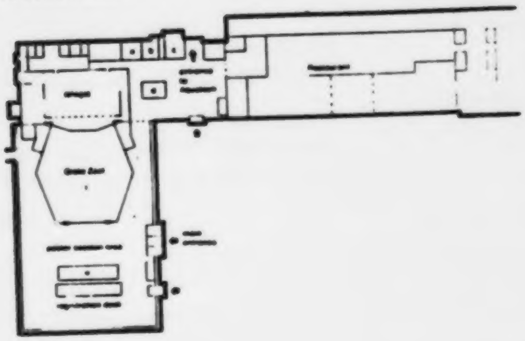
ONRI

- BKH, Consulting Engineers, The Hague
- DHV, Consulting Engineers, Amersfoort
- DSBV, Engineers and Architects, Rotterdam
- Haskoning, Consulting Engineers and Architects, Nijmegen
- Infra-Consult , Consulting Engineers, Deventer
- IWACO, International Water Supply Consultants, Rotterdam
- Mabeg-van Hasselt, Engineers and Architects, Utrecht
- Tebodin, Consulting Engineers, The Hague
- Witteveen + Bos, Consulting Engineers, Deventer

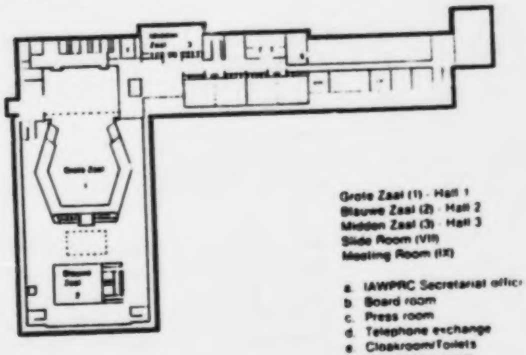
3 Plan of the RAI



Ground Floor



First Floor



Grote Zaal (1) - Hall 1
Blauwe Zaal (2) - Hall 2
Midden Zaal (3) - Hall 3
Slide Room (VII)
Meeting Room (IX)

a. IAWPRC Secretariat offic
b. Board room
c. Press room
d. Telephone exchange
e. Cloakroom/Toilets
f. Interpreters room

4 Technical Sessions

Technical sessions will be held at the RAI Conference Centre in the following three halls:

Hall 1: Ground floor (Grote Zaal)
Hall 2: First floor (Blauwe Zaal)
Hall 3: First floor (Midden Zaal)

The following subjects will be discussed in the three sessions:

	Hall 1	Hall 2	Hall 3
Monday 17 Sept.	• Aerobic Films	• Land Treatment of Waste and Wastewater	• Analysis of Water and Wastewater • Biological Water Quality Assessment
Tuesday 18 Sept.	• Phosphorus Removal • Anaerobic Treatment • Formation and Oxidation of Sulphides	• Sludge	• Resuspension and Sedimentation • Benthal Deposits • Modelling Water Quality • Dispersion in Estuaries
Wednesday 19 Sept.	• Activated Sludge • Kinetics and Aeration in Aerobic Treatment	• Disinfection • Modelling Treatment • Virology • Particles in Surface Waters	• Physical - Chemical Treatment
Thursday 20 Sept.	• Industrial Wastewater Treatment • Nitrification and Denitrification	• Cementation • Eutrophication • Production of Plants and Algae from Wastewater	• Effects of Agriculture on Water Quality • Urban Run-off • Standards • Transport and Processes in Sewers

MONDAY 17 SEPTEMBER

	HALL 1	HALL 2	HALL 3
	Chairman: C.F. Seyfried (FRG) Recorder: K. Krauth (FRG)	Chairman: A. van Haute (Belgium) Recorder: D. Wilms (Belgium)	Chairman: W.J. Weber, Jr. (USA) Recorder: L.H. Keith (USA)
14h00	C 1 Removal of Soluble Substrates in Fixed Films. Jes la Cour Jansen and P. Harremoes, Denmark.	C35 Epidemiological Evidence for Helminth and Cholera Transmission by Vegetables irrigated with Wastewater: Jerusalem - A Case Study. H. Shuval, P. Yekutiel and B. Fattal, Israel.	C69 The Application of Information about Conductivity in the Computing of Ion Concentrations, Illustrated by Certain Surface Waters situated in Lower Saxony. W. Walther, M. Gorsler, J. Poltz and D. Bock, (FRG)
	Discusser: B.H. Olson (USA)	Discusser: E. Isgaard (Sweden)	Discusser: B.M. van Vliet (SA)
14h35	C 2 Influence of Particulate Organics on the Removal of Dissolved Organics in Fixed-Film Biological Reactors. E. Sarner and S. Marklund, Sweden	C36 Wastewater Treatment by Artificial Wetlands. R.M. Ge[illegible], B.V. Elkins and C.R. Goldman, USA	C70 Hazardous Substances in Wastewater. A.B. van Luin and W. van Starkenburg, NL.
	Discusser: A.H. Molof (USA)	Discusser: G.D. Butijn (NL)	Discusser: L.H. Keith (USA)
15h10	C 3 Competition in Biofilms. W. Gujer and O. Wanner, Switzerland	C37 Use of Paracetic Acid in Operational Sewage Sludge Disposal to Pasture. J.A.L. Fraser, A.F. Godfree and F. Jones, UK	C71 Continuous Automatic Detection of Organophosphates and Carbamates in Water Utilizing Enzyme Microcalorimetry. W.S.G. Morgan, P.C. Kühn and P.P. van Niekerk, SA
	Discusser: Y. Watanabe (Japan)	Discusser:	Discusser:

15h45 Refreshment and Poster Presentations

	Chairman: D.F. Toerien (SA) Recorder: P.G.J. Meiring (SA)	Chairman: M. Miloradov (Yugo) Recorder: J.F. Laagland (NL)	Chairman: K. Baalsrud (Norway) Recorder: T. Simensen (Norway)
16h15	C 4 The Effect of Load Fluctuations on the Effluent Concentration produced by Fixed-Film Reactors. B.E. Rittman, USA.	C38 Considerations on Water, Oil and Air in Porous Media. H.O. Schiegg, Switzerland.	C72 Biological Assessment of Water Quality in Running Water using Macroinvertebrates, a case study for Limburg. H.H. Tolkamp (NL)
	Discusser: W.A. Pretorius (SA)	Discusser:	Discusser: F.M. Chutter (SA)
16h50	C 5 Evaluation of Temperature Effects on Trickling Filter Plant Performance. A. Adin, E.R. Baumann and F.D. Warner, Israel.	C39 Leachate Attenuation in the Unsaturated Zone Beneath Landfills: Instrumentation and Monitoring of a Site in Southern England. H.D. Robinson, and J.L. Lucas, UK	C73 Aquatic Habitat Analysis as an Element of Water Resources Planning and Management. E.E. Herricks, USA.
	Discusser: A.B. Wheatland (UK)	Discusser: J.A. van der Schroef (NL)	Discusser: M.W. Hall (USA)
17h25	End		

TUESDAY 18 SEPTEMBER

	HALL 1	HALL 2	HALL 3
	Chairman: J. Bernard (France) Recorder: M. Florentz (France)	Chairman: B. Hawerman (Sweden) Recorder: J. Hultgren (Sweden)	Chairman: P.H. Jones (Canada) Recorder: P. Huck (Canada)
09h00	C 6 The Role of an Anaerobic Stage on Biological Phosphorus Removal. T. Fukase, M. Shibata and Y. Miyaji, Japan	C40 Settling of Nutrient Removal Activated Sludges. A.R. Pitman, (SA)	C74 Erosional Process of Cohesive Sediments. T. Kusada, T. Umita, K. Koga, T. Futawatari and Y. Awaya, Japan
	Discusser: J.B. Carberry (USA)	Discusser:	Discusser: P.L. Brezonik (USA)
09h35	C 7 The Influence of Extended Anaerobic Retention Time on the Performance of Phoredox Nutrient Removal Plants. A., Gerber and C.T. Winter, South Africa	C41 Sludge Conditioning: Effects of Sludge Biochemical Composition. P.T. Bowen and T.M. Keinath, USA	C75 Quantification of Wind Induced Resuspension in a Shallow Lake. R.H. Aalderink, L. Lijklema J. Breukelman, W. v Raaphorst and A.G. Brinkman (NL)
	Discusser: H. Myoga (Japan)	Discusser: R. den Engelse (NL)	Discusser: L. Somlyody (Hungary)
10h10	C 8 Location of Phosphorus in Activated Sludge and Function of Intracellular Polyphosphates in Biological Phosphorus Removal Process. T. Mino, T. Kawakami and T. Matsuo, Japan	C42 Floc-Forming Substances Extracted from Activated Sludge with Ammonium Hydroxide and EDTA Solutions. T. Sato and Y. Ose, Japan	C76 The Behaviour of Suspensed Sediments and Muds in an Estuary. T. Umita, T. Kusuda, Y. Awaya, M. Onuma, T. Futawatari, Japan.
	Discusser: K.E.U. Brodisch (SA)	Discusser:	Discusser:

10h45 Refreshment and Poster Presentations

	Chairman: W. Gujer (Switz.) Recorder: O. Wanner (Switz.)	Chairman: P. Grau (Czech.) Recorder: M. Fiala (Czech.)	Chairman: H. Leskelä (Finland Recorder: R. Timonen (Finland)
11h15	C 9 Modeling Phosphate Sludge Production. R.G. Veldkamp, The Netherlands	C43 Highly Efficient Anaerobic Digestion with Thermal Pretreatment. M. Hiraoka, N. Takeda, S. Sakai, and A. Yasuda, Japan	C77 Stabilization of Organic Carbon and Nitrogen in Consolidating Benthal Deposits. C.W. Bryant, Jr. and L.G. Rich, USA
	Discusser: A. Gerber (SA)	Discusser: J. Malina (USA)	Discusser: J. Lijklema (NL)
11h50	C10 Phosphorus Removal from waste water by Crystallization Method. I. Joko, Japan	C44 Production of Liquid Alum from Aluminium-Anodizing Sludges. F.M. Saunders, and C.B. Harmon, USA	C78 The Calculation of Transport coefficients of Phosphate- and Calcium fluxes across the Sediment-Water Interface, from Experiments with Undisturbed Sediment Cores. W. Raaphorst, and A.G. Brinkmann, The Netherlands
	Discusser:H.N.S. Wiechers (SA)	Discusser:B. Ericsson (Sweden)	Discusser:

12h25 Lunch

	Chairman: D.H. Newsome (UK) Recorder: T.A. Hurker (UK)	Chairman: H. Fleckseder (Austria) Recorder: H. Kroiss (Austria)	Chairman: L. Mendia (Italy) Recorder: G. Biancheri (Italy)
14h00	C11 Phosphate Removal by Crystallization in a Fluidized Bed. J.C. van Dijk and H. Braakensiek, The Netherlands Discusser: P. Dold (SA)	C45 Sludge Treatment Technology and Ionizing Radiation. M. Sedlacek, M. Koubik, K. Vacek and J. Rejholec, Czech. Czechoslovakia Discusser: T. Lessel (FRG)	C79 Stream Modelling of Non-Conventional Water Quality Parameters: Phenol, Cyanide, Ammonia, Oil and Grease. A.B.M. Shahalam and D.A. Burke, Jordan/USA Discusser: D. Hendrikcs (USA)
14h35	C12 Batch Anaerobic Methanogenesis of Phenolic Coal Conversion Wastewater. P.M. Fedorak and S.E. Hudrey, Canada Discusser: F.G. Pohland (USA)	C46 Sludge Stabilisation and Disinfection by Means of Autothermal Aerobic Digestion with Oxygen. B.C. Trim and J.E. McGlashan, South Africa Discusser: J. van der Graaf (NL)	C80 Modelling of Oxygen Depletion in Coastal Waters. A.P. Malmgren-Hansen, Mortensen and B. Moller, Denmark Discusser:
15h10	C13 Thermopilic Anaerobic Contact Digestion of Palm Oil Mill Effluent. A. Ibrahim, B.G. Yeoh, S.C. Cheah A.N. Ma, S. Ahmed, T.Y. Chew, R. Raj and M.J.A. Whaid, Malaysia Discusser: R.E. Speece (USA)	C47 Decontaminating Biological Sludge for Agricultural Use. L. Wong, and J.G. Henry, Canada Discusser: S.K. Banerji (USA)	C81 Water Quality Modelling of the Lower Han River (Korea). L.F. Tischler, R.M. Bradley, S.J. Park and D.G. Rhee, USA/Korea Discusser: T.O. Barnwell (USA)

15h45 Coffee and tea break

	Chairman: J.W. Patterson (USA) Recorder: R.A. Conway (USA)	Chairman: N. Chaudhuri (India) Recorder: H. Ehrhardt (NL)	Chairman: A. Hernandez Munoz (Spain) Recorder: J. Rubio (Spain)
16h15	C14 Oxidation of Sulfide and Thiosulfate and Storage of Sulfur granules in Thiothrix from Activated Sludge. P.H. Nielsen, Denmark Discusser: P.H. King (USA)	C48 Fractionation of Heavy Metals in Sewage Sludges. R.J. Oake, C.S. Booker and R.D. Davies, UK Discusser: A. Netzer (USA)	C82 A Role for a Simple Discrete-Time Model to Describe Dispersion in an Estuary. T. Wood, Australia Discusser: T. Kusuda (Japan)
16h50	C15 Kinetic Studies of the Microbiological Conversion of Sulphate to Hydrogen Sulphide and Their Relevance to Sulphide Generation within Sewers. G.A. Holder, G. Vaughan and W. Drew, Australia Discusser: S. Matsui (Japan)	C49 Controlling Metal Uptake from Heat-Treated Sludge Applied to Grasslands. J.W. Vail and D.G. Devey, South Africa Discusser: S. Hallqvist (Sweden)	C83 Tidal Variation of Salt Flux and Dispersion in a Polluted Estuary. J.K. Park, and A. James, UK Discusser:
17h25	End		

WEDNESDAY 19 SEPTEMBER

	HALL 1	HALL 2	HALL 3
	Chairman: W.C. Witvoet (NL) Recorder: E. Eggers (NL)	Chairman: L. Somlyody (Hungary) Recorder: A.L. Downing (UK)	Chairman: H. Ruffer (FRG) Recorder: J. Baessler (FRG)
09h00	C16 Mixing and Detention Time Distribution in Activated Sludge Tanks. H. Bode and C.F. Seyfried, Federal Republic of Germany Discusser: B. Khudenko (USA)	C50 Disinfection of Drinking Water Rich in Bromide with Chlorine and Chlorine Dioxide, while Minimizing the Formation of Undesirable By-Products. Ch. Rav-Acha, et al., Israel Discusser: R.A. van Steenderen (SA)	C84 Factors Affecting the Adsorption of Complexed Heavy Metals on Hydrous Al_2O_3. H.A. Elliott and C.P. Huang, USA Discusser: I. Joko (Japan)
09h35	C17 Influence of Macromixing on Organic Carbon Uptake and Solids Production by Aerobic Suspended Biomass. S. Elmaleh, T.I. Yoon and A. Grasmick, France Discusser: P.G.J. Meiring (SA)	C51 Sunlight Photo-oxidation of Organic Pollutants in Wastewater. A.J. Archer, Israel Discusser: T. Omura (Japan)	C85 Infrared Thermal Regeneration of Spent Activated Carbon from Water Reclamation. B.M. van Vliet and L. Venter, South Africa Discusser: J.R. Schultz (USA)
10h10	C18 An Equalization Control Strategy for Activated Sludge Process Control. P.L. Dold, H.O. Buhr and G.v.R. Marais, South Africa/USA Discusser: H. Takeda (Japan)	C52 Synthesis Modelling of Municipal Wastewater Treatment Systems. A.S. Camara, C.W. Randall and L.C. Frair, Portugal/USA Discusser: E.L.C. Koster (NL)	C86 Organic Removal Mechanisms in Biophysical Treatment Systems. J.R. Schultz and T.M. Keinath, USA Discusser: F.A. Digiano (USA)

10h45 Refreshment and Poster Presentations

	Chairman: W.W. Eckenfelder (USA) Recorder: D.L. Ford (USA)	Chairman: H.R.H. Hughes (NZ) Recorder: T. Omura (Japan)	Chairman: G. Rivas-Mijares (Ven.) Recorder: P.E. Odendaal (SA)
11h15	C19 The A-B Process: A Novel Two Stage Wastewater Treatment System. A.I. Versprille, B. Zuurveen and Th. Stein, The Netherlands Discusser: P.H.A. de Bekker (NL)	C53 Specific RNA Bacteriophages in Sewage: Methodology and Occurrence. A.H. Havelaar, W.H. Hogeboom and R. Pot, The Netherlands Discusser:	C87 Ozone Enhanced Biological Activated Carbon Filtration and Its Effect on Organic Matter Removal, and in Particular on AOC Reduction. J.G. Janssens, J. Meheus and J. Dirickx, Belgium Discusser: M.J.A. Vennekens (SA)
11h50	C20 Flexible Modelling of the Activated Sludge System - Theoretical and Practical Aspects. M.S. Sheffer, M. Hiraoka and K. Tsumura, Israel/Japan Discusser: W.W. Eckenfelder (USA)	C54 Inactivation of Hepatitis A Virus, Other Enteric Viruses and Indicator Organisms in Water by Chlorination. W. Grabow, P. Coubrough, C. Hilner and B.W. Bateman Discusser:	C88 Ozonation of Non-Ionic Surfactants in Aqueous Solutions. N. Narkis, B. Ben-David and M.S. Rotel, Israel Discusser: F.M. Saunders (USA)

12h25 Lunch

	Chairman: B.B. Sundaresen (India) Recorder: M.R. Henzen (SA)	Chairman: W.O.K. Grabow (SA) Recorder: G. Mabale (SA)	Chairman: T. Matsuo (Japan) Recorder: Y. Watanabe (Japan)
14h00	C21 Determination of Kinetic Constants of Activated Sludge Micro-Organisms. J.S. Cech, J. Chudoba and P. Grau, Czechoslovakia Discusser: C.P.L. Grady (USA)	C55 Effects of Water Quality on Microporous Filter Methods for Enteric Virus Concentration. M.D. Sobsey, T. Cromeans, A.R. Hickey, and J.S. Glass, USA Discusser: L. Leong (USA)	C89 Influence of Bubble Sizes on Ozone Solubility Utilization and Disinfection. M. Ahmad and S. Farooq, Saudi Arabia Discusser: R.A. Sierka (USA)
14h35	C22 The Potential Use of Enzymes for Removal of Aromatic Compounds from Water. S.W. Maloney, J. Manem, J. Mallevialle, and F. Fiessinger, (France) Discusser:	C56 Factors Controlling the Survival of Viruses in Groundwater. M.V. Yates, and C.P. Gerba, USA Discusser:	C90 The Role of Rapid Mixing Time on a Flocculation Process. R.J. Francois, and A.A. Van Haute, Belgium Discusser: C.R. O'Melia (USA)
15h10	C23 Development of Pollutant Specific Models for Toxic Organic Compounds in the Activated Sludge Process. A.T. Watkin and W.W. Eckenfelder, Jr. USA Discusser: W.J. Weber (USA)	C57 Occurence of Viruses in Treated Drinking Water in the United States. E.W. Akin, USA Discusser: E.M. Nupen (SA)	C91 Management of Urban Wastewater Physico-Chemical Treatment Stations: Servocontrol of Reagent Additions at the Quiberon Sewage Treatment Plant St.Pierre Quiberon. P. Marchandise, J.P. Legendre, D. Delacroix and J.L. Rivoal, France Discusser: F.B. van der Walle (NL)

15h45 Coffee and tea break

	Chairman: T.M. Keinath (USA) Recorder: F.M. Saunders (USA)	Chairman: L. Coin (France) Recorder: C. Basalo (France)	Chairman: J.M. Novais (Portugal) Recorder: M.H.M. Monte (Portugal)
16h15	C24 The Kinetic Analysis of BOD and Nitrogen Removal in an Oxidation Ditch. Y. Terashima and M. Ishikawa, Japan Discusser: G.v.R. Marais (SA)	C58 Colloidal Stability of Particles in Lakes: Measurement and Significance. W. Ali, C.R. O'Melia and J.K. Edzwald, USA Discusser: A. Downing (UK)	C92 Modelling of the Coagulation-Adsorption Process in Treatment Systems. A.M. Dziubek and A.L. Kowal, Poland Discusser:
16h50	C25 Steady State Measurement of Oxygenation Capacity. K. de Korte and P. Smits, The Netherlands Discusser: J.E. Alleman (USA)	C59 Sorption of Ammonia Nitrogen on River Borne Suspended Solids. R.F. Wukasch and L.P. Moos, USA Discusser: E.R. Baumann (USA)	C93 Hexavalent Chromium Removal from Drinking Water. J.M. Phillipot, F. Chaffange and J. Sibony, France Discusser: J.W. Patterson (USA)
17h25	End		

THURSDAY 20 SEPTEMBER

	HALL 1	HALL 2	HALL 3
	Chairman: M. Hiraoka (Japan) **Recorder:** T. Kusuda (Japan)	**Chairman:** H.R. Eisenhauer (Canada) **Recorder:** H. Meicer (Canada)	**Chairman:** K.J. Ives (UK) **Recorder:** A.B. Wheatland (UK)
09h00	C26 Removal of Iron Cyanide from Gold Mill Effluents by Ion Exchange. D.T. Vachon, Canada **Discusser:**	C80 Mechanism and Kinetics of Cementation Process. B.M. Khudenko, USA **Discusser:** E.S.K. Chian (USA)	C94 The Contribution of Agricultural Loading to Eutrophication in Finnish Lakes. L. Kauppi, Finland **Discusser:** J.N.M. Vinken (NL)
09h35	C27 Total Effluent Treatment and Rinse Water Reclamation in a Semiconductor Device Manufacturing Facility. P.S. Cartwright, USA **Discusser:** W. Maaskant (NL)	C81 Phosphorus, Nitrogen & Chlorophyll A Concentrations in a Typical Dutch Polder Lake, Tjeukemeer, in Relation to its Water Regime Between 1968 & 1982. De Haan H. and J.R. Moed, The Netherlands **Discusser:**	C95 Modelling Water Quality and the Effects of Agricultural BMPs in the Iowa River Basin. B.R. Bicknell, A.S. Donigian, Jr. and T.O. Barnwell, USA **Discusser:**
10h10	C28 Development of a New Process for Treating Uranium Mining Effluents. P.M. Huck, W.B. Anderson and R.C. Andrews, Canada **Discusser:**	C82 The Role of Phytoplankton in the Dissolved Oxygen Budget of a Stratified Estuary. P.G. Soulsby, M. Mollowney, G. Marsh and D. Lowthion, UK **Discusser:**	C96 Surface Water Quality in Relation to Soil Type, Land Use and Discharge in a Rural Catchment Area. M.C.H. Witmer, The Netherlands **Discusser:** A.A. Afifi (USA)

10h45 **Refreshment and Poster Presentations**

	Chairman: E.J. Hall (SA) **Recorder:** G.C.D. Claassens (SA)	**Chairman:** B. Jost (Switz.) **Recorder:** H.P. Walser (Switz.)	**Chairman:** P. Harremoes (Denmark) **Recorder:** J. la Cour Jansen (Denmark)
11h15	C29 Dynamics of Nitrification in a Biological Fluidized Bed Reactor. S.W. Hermanowicz, and Jerzy J. Ganczarczyk, USA/Canada **Discusser:** Y. Terashima (Japan)	C83 Restoration of Lake Veluwe by Reduction of Phosphorus Loading and Flushing. S.H. Hosper, The Netherlands **Discusser:** A.S. Hoogendoorn (NL)	C97 Chronic Pollution of Intercity Motorway Runoff Waters. J.D. Balades, M. Cathelain, P. Merchandise, J. Peybernard, and J.C. Pilloy, France **Discusser:** E.R. Christensen (USA)
11h50	C30 Modelling, Optimization & Design of Fluidized Beds for Biological Denitrification. Th.J. Nieuwstad, The Netherlands **Discusser:** J. la Cour Jansen (Denmark)	C84 Water Quality Control of the Andelse Maas Basin by Iron Dosing. A.C. Hoekstra and K.D. Malwald, The Netherlands **Discusser:**	C98 Collection and Analysis of Urban Runoff Data in Finland. M.J. Melanen, Finland **Discusser:** H.C. Preul (USA)

12h25 **Lunch**

	Chairman: B. Ericsson (Sweden) Recorder: L. Gunnarsson (Sweden)	Chairman: R.G. Ludwig (Brazil) Recorder: S.A.S. Almeida (Brazil)	Chairman: L. Henry (Australia) Recorder: L. Lijklema (NL)
14h00	C31 Mathematical Model of Simultaneous Organic Oxidation, Nitrification and Denitrification in Rotating Biological Contactors. Y. Watanabe, S. Masuda, K. Nishidome, and C. Wantawin, Japan/Thailand	C65 Treatment of Agro-Industrial Wastes Using Water Hyacinth. C.K. John, Malaysia	C99 Marine Quality Standards. Their Derivation and Application in The United Kingdom. G. Mance and A.R. O'Donnell, UK
	Discusser: H. Odegaard (Norway)	Discusser: H.R. Hughes (NZ)	Discusser: J. McGlashan (SA)
14h35	C32 The Application of Predenitrification-Nitrification Technology for Trace Contaminant Control. H. Melcer and S.G. Nutt, Canada	C66 The Selective Cultivation of Easily Harvestable Algae Using Crossflow-Microscreening. W.A. Pretorius and L.C. Hensman, South Africa	C100 The EEC Shellfish Directive in Wales. S.N. Young and P. Wathern, UK
	Discusser:	Discusser: K.J. Ives (UK)	Discusser:
15h10	C33 Elevated Nitrite Occurence in Biological Wastewater Treatment Systems. J.E. Alleman, USA	C67 Waste Water Recycling by Duckweed for Protein Production and Effluent Renovation. G. Oron, L.R. Wildschut and D. Porath, Israel/The Netherlands	C101 Operation and Efficiency of Automatically Operating Weir Structures, A Contribution to Cleaner Waters. E. Macke, Federal Republic of Germany
	Discusser: W. Gujer (Switz.)	Discusser: D.F. Toerien (SA)	Discusser:
15h45	C34 Single Sludge Anoxic-Aerobic Systems for Biological Treatment of Coke Plant Wastewaters. M. Beccari, A.C. Di Pinto, R. Passino, R. Ramadori, and V. Tandoi, Italy	C68 A Potential Treatment Alternative for Swine Wastewater in the Tropics. P.Y. Yang and S.Y. Nagano, USA	C102 Sedimentation, Mineralization and Resuspension of Sludge in a Sewerage System; A Case Study. A.S. Hoogendoorn-Roozemond, The Netherlands
	Discusser: G. Ekama (SA)	Discusser: P.E. Odendaal (SA)	Discusser: J. Tyson (UK)
16h20	End		

5 Briefing Sessions for Authors, Chairmen, Recorders, Discussers and Interpreters

Briefing sessions for authors, session chairmen, recorders invited discussers and interpreters will be held each day in the specific halls in which they will present their paper or do duty that day. The briefing periods will commence at the following times:

Monday 17 September : 13h30
Tuesday 18 September : 08h30 and 13h30
Wednesday 19 September: 08h30 and 13h30
Thursday 20 September : 08h30 and 13h30

The persons who will lead the briefing sessions in the three halls are:

Hall 1: Prof. Dr. L. Lijklema
Hall 2: Mr. A. Milburn
Hall 3: Ir. J. van Selm

IMPORTANT NOTE FOR AUTHORS: SLIDES FOR PROJECTION

1. Authors should hand over their slides to the technician on duty in the hall where they will present their paper immediately before the start of the session during which they will make their presentation. Authors should collect their slides and check them at the end of the session.
2. A slide viewing room (Hall VII) will be available next to Hall 3 on the first floor of the conference centre for authors who wish to screen or examine their slides beforehand.
3. Overhead projection equipment for transparencies will be available in each hall.

6 Poster sessions

Authors of poster presentations must be in attendance at their posters according to the following timetable. In addition, special appointments can be made with authors on appointments pads which will be available on each author's table.
Monday 17 September 15h45 - 16h15
Tuesday 18 September 10h45 - 11h15
Wednesday 19 September 10h45 - 11h15
Thursday 20 September 10h45 - 11h15

The following posters will be exhibited on the ground floor next to the entrance of the conference centre and Hall 1:

P 1. The Urban Water Research Project, Lelystad, F. van der Ven and E. Uunk, The Netherlands.
P 2. Surveying Tidal Fluxes of Metals through the Mersey Narrows, 1982 & 1983, K. Whitelaw, J. Cole, P. Head and P. Jones, UK.
P 3. A Modular Water Treatment Package for Surface Waters in Rural Locations of Developing Countries Incorporating Novel Design & Operational Features, B. Lloyd, D. Wheeler and M. Pardon, UK.
P 4. A Low Cost Portable Water Testing Kit for Developing Countries, B. Lloyd, D. Wheeler and M. Snook, UK.
P 5. Investigations on the Anaerobic-Aerobic Treatment of a High Concentrated Wastewater, A. Mennerich, W. Germany.
P 6. Water Quality Models Based on Thermodynamics of Accumulation Processes Regularities, M. Mehandjiev, Bulgaria.
P 7. Evaluation of a Sludge Treatment Process with Thermal Conditioning, L. Spinosa, Italy.
P 8. A Fixed Bed Reactor and a Stirred Reactor Compared in the Case of Anaerobic Wastewater Treatment, S. Kunst and K. Mudrack, W. Germany.
P 9. Chlorinated Phenols and their Derivatives in Soil and Groundwater Around Wood-Preserving Facilities in Finland, R. Valo, V. Kitunen, M.S. Salkinoja and S. Räisänen, Finland.
P10. Upgrading of Existing Sewage Treatment Plants, T. Muller and J. Janus, The Netherlands.
P11. New Design Guidelines for Circular and Rectangular Final Settling Tanks, R. Epskamp and F. Hernen, The Netherlands.
P12. Groundwater Pollution Resulting from the Disposal of Wastes in the 'Volgermeer polder' Situated North of Amsterdam, J. van der Schroeff, The Netherlands.
P13. Effect of Soil Particles and Autochtonous Particulate Matter on the Fate of Parathion in Water, A. Gasith, D. Goldman and A. Perry, Israel.
P14. Algal Growth Potential Test: An Indicative Method to Estimate the Influence of Water Quality Changes on the Algae Biomass, G. Boller, The Netherlands.
P15. Center for Water Quality Modeling, T. Barnwell, USA.
P16. Prediction of Nutrients and Chlorophyll in the Future Freshwater Basin Volkerakmeer/Zoommeer, The Netherlands, G. van Eck and N.M. de Rooij, The Netherlands.
P17. Predictions of Micropollutants in the Future Freshwater Basin Volkerakmeer/Zoommeer, The Netherlands, E. van der Vrie, G. van Eck and N.M. de Rooij, The Netherlands.
P18. Prediction of Chloride in the Future Freshwater Basin Volkerakmeer/Zoommeer, The Netherlands, J. Bakker and N.M. de Rooij, The Netherlands.
P19. Control of Salinity in the Coastal Groundwater of Indian Peninsular, P. Basak, S. Abraham, India.
P20. The Lagoon of Santa Gilla (Sardinia): Present Conditions and Possibilities of Restoration, A. Contu, P. Mulas, G. Sarritzu, M. Schintu, N. Sechi and A. Ulzega, Italy.
P21. Streambank and Instream Habitat Restoration of Foothills Creeks Affected by Oil and Gas Activities, M. Polet and J. Allan, Canada.
P22. Optimization Modelling for the Selection of an Abatement Program for Diffuse Agricultural Pollutants, J. Cousins and E. McBean, Canada.

P23. Flotation and Membrane Treatment of Industrial Wastewaters, O. Hart and R. Squires, South Africa.
P24. Artificial Wetlands as Tertiary Wastewater Treatment Systems, J. de Jong, The Netherlands.
P25. Remineralization and Potabilization of Desalinated Water, Y. Henderyckx, Belgium.
P26. Study of Viral Pollution at the East Lake in Wuchang, Z. Chu-Yu, China.
P27. Estimation of Mutagenic Activities and Physico-Chemical Indexes of Coastal Sea Waters, N. Kinae, M. Yamashita, T. Watanabe, M. Takahashi, S. Yamamoto and I. Tomita, Japan
P28. Application of Stripping Voltammetry to Survey the Trace Metals in River Waters, B. Singh and S. Pathak, India.
P29. Biological Treatment of Phenolic Wastewater in a Three-Phase Fluidized Bed, Y. Hosaka, M. Kaihou and A. Hirata, Japan.
P30. The Influence of Substances Polluting Water on Electrophysiological Indexes of Olfactory and Visual System of Fish, S. Tagiev and A. Ismailov, USSR.
P31. New Contribution on Surface and Subsurface Water Relationship in Egypt Using Radio Isotopic Model for the River Nile, B. Mabrook, F. Swelim and R. El Sheikh, Egypt.
P32. Fate and Effect of Copper on the Performance of a Rotating Biological Contactor, F. El Gohary, M. Lasheen, M. Saleh and A. Ashmawy, Egypt.
P33. The Response of Aquatic Organisms to Mixtures of Toxicants, E. Christensen, C. Chen and J. Kannall, USA.
P34. Distribution of Suspended Particulate Matter Near Orange County, California, Sewage Outfall, R. Kolpack, USA.
P35. Dynamic Response of Final Clarifiers, J. Dietz and T. Keinath, USA.
P36. Boron Removal With Resin and its Formulation, D. Topacik and S. Sahin, Turkey.
P37. The Surfactant Profile of Municipal Wastewater: Influents and Effluents, U. Zoller, Israel.
P38. Complete Reclamation of Wastewater and Sludge, B. Elkins, G. Wilson and R. Gersberg, USA.
P39. Environmental Acidification and its Consequences for the Toxicity of Weak Acids and Bases to Aquatic Organisms, I. van der Putte and M. Brinkhorst, The Netherlands.
P40. Modelling the Phosphate Concentration in a Shallow Lake, with Special Emphasis on the Effects of Sediment-Water Exchange, P. Kelderman and A. Verwey, The Netherlands.
P41. A. Seasonal Study on the Distribution of Mercury in the River Cooum in Madras, K. Ayyadurai and V. Krishnasamy, India
P42. Partial Extraction of Metals from Soil to Evaluate Pollution, C. Randall, C. Donaldson, P. Wigington, T.J. Grizzard and W.R. Knocke, USA.
P43. Investigation for and the Design and Construction of a Submarine Outfall Pipeline into Bass Strait, Victoria, Australia, J.J. Ryan, Australia
P44. Mass Transfer Mechanisms in a Heterotrophic Biofilm, H. Siegrist and W. Guyer, Switzerland.
P45. Aqueous Suspension Based Abrasion Resistant Assessment for Particulate Activated Carbons, M. Vennekens and B. van Vliet, South Africa.
P46. Anoxic-aerobic Digestion of Waste Activated Sludge, A. Warner, G. Ekama and G. Marais, South Africa
P47. Axial Dilution in an Obstructed Round Vertical Turbulent Buoyant Jet, G. Noutsopoulos and P. Yiannopoulos, Greece.
P48. Evalution of Alternative Measures for Controlling Pollution in part of West Morava River Basin, A. Filip and D. Obradovic, Yugoslavia
P49. Recent Studies of Systems for Small Scale Wastewater Treatment in the Netherlands, J. van der Graaf and H. Webers, The Netherlands.

P50. Modelling of Hypolimnic Water Quality in Deep Pits Created by Sand Dredging in the Lake IJssel Area, J. van Pagee, J. Smits and J. de Wit, The Netherlands.
P51. An Evalution of Management Aspects of a Hypertrophic African Impoundment, J. Thornton, K. Cochrane, A. Jarvic, T. Zohary, R. Roberts and F. Chutter, South Africa.
P52. Wastewater Treatment using Aquatic Plants. Survivability and Growth of Salvinia Molesta Mitchell over Waters Treated with Zinc (II) and the Subsequent Utilization of the Harvested Weeds for Energy (Biogas) Production, S. Abbasi and P. Nipaney, India.
P53. Biological Treatment of Industrial Wastewater in a Two-Staged Anaerobic Fluidized Bed Reactor, J. Heijen and W. Enger, The Netherlands.
P54. Application of the UASB Reactor for Anaerobic Treatment of Brewery Effluent, P. Hack, The Netherlands.
P55. Pollution Emission from Sewer Systems, D. Vat, The Netherlands.
P56. Wastewater Treatment Plants in Amsterdam, R.R. Kruize, The Netherlands.

The following Virology Posters will be displayed in the RAI from Monday 17 September to Wednesday 19 September, and in Bilthoven on Thursday and Friday, 20-21 September during the specialist technical meeting on Water Virology.

V 1. The influence of isoelectric point on the inactivation of viruses by chlorine, G.R. Taylor and M. Butler, UK.
V 2. Virological research on behalf of the Netherlands waterworks, M. van Olphen and E. van de Baan, The Netherlands.
V 3. Reduction of viruses in river by storage in open reservoirs, M. van Olphen, J.G. Kapsenberg, E. van de Baan and A. Franke, The Netherlands.
V 4. Detection of indigenous enteric viruses in raw sewage effluents of the city of Athens (Greece) during a two year survey, V. Krikelis, N. Spyrou and C. Serie, Greece.
V 5. Failure to detect cytopathic enteroviruses in drinking water, R. Morris and D.N. Sharpe, UK.
V 6. Behaviour of coliphages in oxidation ponds, T. Omura, H.K. Shin and A. Ketratanakul, Japan.
V 7. Reduction of viruses in river water by storage in open reservoirs, M. van Olphen, J.G. Kapsenberg, E. van de Baan and A. Franke, The Netherlands.
V 8. Detection of hepatits A virus (HAV) in drinking water, M.D. Sobsey, S.E. Oglesbee and D.A. Wait, USA.
V 9. Examination of the penetration of enteric viruses in soils under simulated conditions in the laboratory, P.H. Jorgensen, Denmark.
V10. Efficiency of coagulation on filter and settling in relation to indigenous virus removal from water: effect of prechlorination, M. Conan, J.C. Joret, A. Hassen, F. Agbalika, Y. Richard and P. Hartemann, France.
V11. Study of indigenous virus removal at different stages in an industrial treatment plant producing drinking water from river water, F. Agbalika, P. Hartemann, J.C. Joret, A. Hassen and M. Bourbigot, France.
V12. Virus removal by activated sludge treatment, E. Shimohara, S. Sugishima and M. Kaneko, Japan.
V13. Studies on the survival of viruses in fully digested sludge after application to grazing land, A. Field and J. Sellwood, UK.
V14. Some experimental discussion of accuracies in quantitative virus assessment for water supply, H. Sumitomo, A. Kimura, T. Nakano, M. Ozaki and J. Imai, Japan.
V15. Detection of hepatitis A virus in drinking water by enzyme-immunoassay using ultracentrifugation for virus concentration, A. Schnattinger, Austria.
V16. Genomic analysis of RNA viruses from effluent, M.T. Hodgkiss and J.W. Moodie, South Africa.
V17. Inactivation of hepatitis A virus by heat and formaldehyde, B. Flehmig, A. Billing, A. Vallbracht and K. Botzenhart, Federal Republic of Germany.

7 Specialist Technical Meetings

Two specialist technical meetings will be organized during the conference.
Delegates who indicated interest in these on their registration forms, should note the following

1. Meeting of the IAWPRC Study Group on Virology.

Wednesday 19 September

Hall 2

10h10 - 15h45	Papers on Water Virology will be presented. More detailed information is given under Technical Sessions.
16h15 - 17h30	Open Meeting of the IAWPRC Study Group on Water Virology in Hall IX.

Thursday 20 September

08h00	Bus departs from RAI Centre to Bilthoven
08h45 - 09h00	Reception with coffee Briefing session for chairmen and authors
09h00 - 09h10	Introduction: W.O.K. Grabow (South Africa)
09h10 - 09h20	Welcome: Prof. Dr. E.J. Ruitenberg; Director, Division of Microbiology and Immunology, RIVM.
	SESSION 1
	Chairman: M.D. Sobsey (USA)
09h20 - 09h50	Detection of rotavirus in treated drinking water B.H. Keswick, C.P. Gerba, J.B. Rose and G.A. Toranzos (USA).
09h50 - 10h20	Rotavirus survival in raw and treated waters and its health implications S.A. Sattar, R.A. Raphael and V.S. Springthorpe (Canada)
10h20 - 10h50	Analysis of tap water for viruses: results of a survey N. Guttman-Bass and B. Fattal (Israel)
10h50 - 11h15	**Refreshments and poster presentations**
	SESSION 2
	Chairman: H.I. Shuval (Israel)
11h15 - 11h45	Viruses and bacteria in a chalk well J.S. Slade (UK)
11h45 - 12h15	Detection and health risk associated with low virus concentration in drinking water P. Payment and M. Trudel (Canada)
12h15 - 12h45	Coliphages and enteroviruses in wastewater effluents and the immune status of occupationally exposed wastewater treatment plant workers A. Simkova and A. Petrovicova (Czechoslovakia)
12h45 - 14h00	**Lunch**
13h45 - 14h00	Briefing session for chairman and authors
	SESSION 3
	Chairman: M. Kaneko (Japan)
14h00 - 14h30	Concentration of seeded and naturally occurring enteroviruses from waters of varying quality by hollow fiber ultrafiltration E.A. Bicknell, D.M. Dziewulski, L.S. Sturman and G. Belfort (USA)

14h30 - 15h00	The recovery of viruses from drinking-water by means of an in-line electropositive cartridge filter E.M. Nupen and B.W. Bateman (South Africa)
15h00 - 15h30	**Refreshments and poster presentations**
15h30 - 16h00	Concentration of viruses from water using pig erythrocyte ghost cells R. Armon, Y. Kott and Y. Neeman (Israel)
16h00	Bus departs from Bilthoven to RAI Centre

Friday 21 September

08h00	Bus departs from RAI Centre to Bilthoven
08h45 - 09h00	Reception with coffee Briefing session for chairmen and authors

SESSION 4

	Chairman: M. Butler (UK)
09h00 - 09h30	Bacteria and viruses in aerobically digested sludge: influence of physical and chemical treatments on survival and association with flocs under laboratory conditions S.R. Farrah, P.R. Scheuerman, R.D. Eubanks and G. Bitton (USA)
09h30 - 10h00	Virus inactivating effect of anaerobic mesophilic digestion of municipal sewage sludge without or with different preceding types of treatment M. Leuze, M. Saier, K. Koch and J. Wekerle (Federal Republic of Germany)
10h00 - 10h30	Detection and stability of enteric viruses in sludge, soil and groundwater P.H. Jorgensen and E. Lund (Denmark)
10h30 - 11h00	**Refreshments and poster presentations**

SESSION 5

	Chairman: S.A. Sattar (Canada)
11h00 - 11h30	Interactions between biotic and abiotic factors and viruses in a water system R. Walter, H. Grahneis, J. Durkop and L. Broschinski (German Democratic Republic)
11h30 - 12h00	Detection of enteroviruses: an assessment of ten cell lines R. Morris (UK)

INTRODUCTION TO TECHNICAL VISITS

12h00 - 12h15	Studies on human enteric viruses and bacteriophages in drinking water supplies M. van Olphen (Keuringsinstituut voor Waterleidingartikelen, Rijswijk)
12h15 - 12h25	Rapid typing of enteroviruses; detection of rotaviruses and adenovirus types 40 and 41 in faeces J.G. Kapsenberg (RIVM)
12h25 - 12h35	Animal cell technology for production of biological products A.L. van Wezel (RIVM)
12h35 - 12h45	Bacteriophages as virus models in water treatment processes A.H. Havelaar (RIVM)
12h45 - 14h00	**Lunch**

TECHNICAL VISITS

14h00 - 15h20	Visit to KIWA laboratories Host: M. van Olphen
15h20 - 15h40	**Refreshments and poster presentations**
15h40 - 16h40	Visit to RIVM laboratories Host: A.H. Havelaar

CLOSING SESSION

Chairman: E.W. Akin

16h40 - 17h30	Open discussion of proceedings and future research needs and priorities; closure by the Chairman
17h30	Bus departs from Bilthoven to RAI Centre

2. Seminar on Pollution Management in Developing Countries at the International Institute for Hydraulic and Environmental Engineering in Delft.

Thursday, 20 September

08h30	Bus departs from RAI Centre to Delft. Participants are requested to report at the information desk in the RAI.
09h30 - 09h50	Reception with coffee at the IHE in Delft
09h50 - 10h10	Opening by representatives of sponsoring organizations
10h10 - 10h40	Design, Maintenance and Operation of Alternative Wastewater Collection and Treatment Systems in Developing Countries, L.A. van Duijl, Senior lecturer IHE.
10h40 - 11h00	Discussion
11h00 - 11h20	**Coffee**
11h20 - 11h45	World Bank Activities on Behalf of Water Pollution Control Projects, J.M. Kalbermatten, Chief Advisor, Water and Sanitation Educational Programmes, World Bank.
11h45 - 12h10	Manpower Needs for Water Pollution Control, Prof. Ir. L.J. Mosterman, Director IHE.
12h10 - 12h40	Discussion
12h40 - 14h00	**Lunch**
14h00 - 14h30	Training of Operators for Wastewater Collection Systems and Treatment Plants in Developing Countries, R.P.J. Turrell Chief Executive, British Water International.
14h30 - 14h40	Discussion
14h40 - 15h10	**Tea**
15h10 - 15h30	Decision Analysis for River Basin Management, Ir. W. Spaans, lecturer IHE.
15h30 - 15h40	Demonstration
15h40 - 16h00	Discussion and practical exercises.
16h00	Bus departs from Delft to the RAI Conference Centre.

8 Technical Excursions

On Friday 21 September a programme of technical excursions will be organized.
All excursions will depart at 08h30 from the RAI Conference Centre.
The participants should report to the bus park next to the Holland Hall, see plan of the RAI (P4).
A description of the technical visits is included in the special conference issue of the journal H_2O, which is in your conference bag.
Further information will be given during the excursions.

An invitation card for the excursion for which you have registered is included in your conference bag. It is important to bring this card with you.
Delegates who have not registered yet for an excursion should contact the excursion information desk (at the registration desk), which will be open from Tuesday 18 September until Thursday 20 September from 12h00 to 14h00.
Some excursions have a maximum capacity. Reservations will be handled on a "first come, first served" basis.

1. Deltaworks.

08h30	Departure from the RAI
11h00	Arrival at the Deltaworks "Neeltje Jans"
13h30 - 15h00	Lunch at the "Zeeuwse Stromen" in Renesse
15h00	Departure from Renesse
17h30	Arrival in Amsterdam

During the trip from Amsterdam to the Deltaworks and during the trip back to Amsterdam a number of specific sites, which are part of the Deltaworks project, will be visited. Representatives of the Deltadienst of the Ministry of Public Works will provide information during these trips. Tour Manager: Ir. K.C. Zijlstra.

2. Drinking Water Reservoirs in the Biesbosch.

08h30	Departure from the RAI.
10h15	Arrival at the "Petrusplaat" in the Biesbosch area.
10h30 - 12h00	Introduction, short lectures and discussion on drinking water supply in the Netherlands and especially in the delta area of the rivers Rhine and Meuse.
12h00 - 13h00	Visit to technical installations at the plant and a quick lunch.
13h15 - 16h00	Trip by boat to the water storage reservoirs in the Biesbosch.
16h15 - 16h45	Visit to the Biesbosch museum.
16h45	Departure to Amsterdam.
17h30	Arrival in Amsterdam.

Tour Managers: Prof. Dr. P.G. Fohr
Prof. Ir. P.L. Knoppert
Drs. G. Oskam
Ing. H. Werkendorp

3. Water Quality Control in the Area of Rotterdam and Visit to the Shell Plant at Pernis.

08h30	Departure from the RAI.
09h30	Arrival at the offices of the Water Board of Delfland in Delft.
09h30 - 10h45	Short lectures on the tasks and organization of Water Boards in the Netherlands by the "Dijkgraaf" of Delfland, and the President of the Water Board of "Hollandse Eilanden en Waarden"
11h10	Arrival at the wastewater treatment plant "De Groote Lucht" in Vlaardingen.
12h30	Departure to Pernis.
13h00 - 14h15	Welcome and lunch by the Shell Petroleum Company at Pernis.
14h15 - 15h00	Introduction to the wastewater treatment plant of Shell Pernis by Ir. C.H. Dorgelo.
15h00 - 16h30	Visit to the industrial wastewater treatment plant of Shell.
16h30	Departure to Amsterdam.
17h30	Arrival at the RAI.

Tour Managers: Ir. C.H. Dorgelo
Ir. H.A. Meijer
Ing. Neiman
Mr. H.A. van der Schilt
Ir. M.D. Sinke
Mr. H.B. Smaal

4. Wastewater Treatment in Amsterdam.

09h00	Departure from the RAI.
09h30	Arrival at the Wibauthuis, the offices of Amsterdam's Public Works Department.
09h45	Welcome and introduction by the Director of the Sewerage and Drainage Department, Ir. M.K.H. Gast.
11h15	Departure from the Wibauthuis.
11h45	Visit to the pumping station "Zeeburg".
12h15	Departure by boat from pumping station "Zeeburg".
13h00 - 14h00	Lunch.
15h00 - 16h15	Visit to the industrial wastewater treatment plant "Groote IJpolder".
16h45	Arrival at the RAI.

Tour Managers: Ir. M.K.H. Gast
Mr. S. Hespe

5. Water Authority of Rijnland

08h30	Departure from RAI conference centre.
10h00 - 10h15	Welcome by the "Dijkgraaf" of the Waterboard of Rijnland.
10h25 - 11h00	Visit to the offices of Rijnland.
11h30 - 13h00	Visit to the wastewater treatment plant "Zwaanshoek".
13h15 - 14h45	Lunch at "De Zoete Inval" at Haarlemmerliede.
15h15 - 16h30	Visit to the Rijnland pumping-station "Halfweg".
16h30	Departure to Amsterdam.
17h00	Arrival at the RAI.

Tour Manager: Mr. J.W.B. Nienhuis

6. Land Reclamation in the Former Zuiderzee

08h30	Departure from RAI Conference Centre.
08h30 - 10h00	Tour of the dykes of the new polders in the IJsselmeer (South and East Flevoland and North East Polder).
10h10	Arrival at "De Voorst", Laboratory of the Delft Hydraulics Laboratory.
10h00 - 10h15	Reception and welcome.
10h15 - 12h00	General introduction to the organisation and activities of the Delft Hydraulics Laboratory. Tour of the laboratory complex and inspection of research facilities.

12h00 - 12h15	Departure to the Information Centre "New Land" near Lelystad.
13h00 - 14h00	Lunch at the information centre "New Land".
14h00 - 14h30	Short film, on the development of Holland.
14h30 - 15h30	Short lectures on ground and surface water management in the Lake IJsselmeerpolders.
15h30 - 17h00	Tour through Flevoland of the experimental sites of the Urban Water Research Project in Lelystad and an infiltration pond.
17h00	Departure to Amsterdam.
17h30	Arrival at the RAI.

Tour Manager: Mr. C.L.C. Verlaan
Ir. F.H.M. van der Ven
Ir. E.J.B. Uunk

7. Netherlands Water Works Testing and Research Institute KIWA and Anaerobic Wastewater Treatment at the Sugar Company C.S.M.

08h30	Departure from RAI conference centre.
09h30 - 09h45	Reception and welcome.
09h45 - 10h00	Introduction.
10h00 - 10h30	Film on the research work of KIWA.
10h30 - 12h00	Visit to the laboratory and research facilities.
12h00	Departure to Breda.
13h00 - 14h00	Lunch at the Motel Breda.
14h00 - 14h30	Introduction to the anaerobic wastewater treatment process at CSM, Breda.
15h00 - 16h30	Visit to the sugar factory of CSM, the laboratory and installations for wastewater treatment.
16h30	Departure to Amsterdam.
17h30	Arrival at the RAI.

Tour Managers: Ir. J.J. Cappon
K. Byleveld (KIWA)
Dr. Ir. R.J. Zoetemeijer (CSM).

8. Hydraulics Laboratory Delft and the Anaerobic Reactor of Gist Brocades.

08h30	Departure from RAI conference centre.
09h30	Arrival at Delft Hydraulics Laboratory.
09h30 - 09h45	Reception and welcome.
09h45 - 12h00	General introduction to the organisation and activities. Introduction to Delft Hydraulics Laboratory's involvement in environmental hydraulics and water resources management. Tour of the laboratory complex and inspection of research facilities.
12h30	Arrival at the Recreation Building "De Tent" in the Agnetapark, Delft.
13h00 - 14h00	Lunch as guests of Gist Brocades
14h00 - 15h00	Three short lectures as an introduction to the excursion to the pilot factory.
15h00 - 16h00	Visit to the pilot factory where laboratory and pilot experiments on wastewater treatment are carried out. A full scale anaerobic fluidized bed reactor will also be visited.
16h00 - 16h30	Discussion.
16h30	Departure to Amsterdam.
17h30	Arrival at the RAI.

Tour Manager: Ir. A.B. van Luin
(experts from Delft Hydraulics Laboratory and Gist Brocades)

9 Aquatech Exhibition

Aquatech is the leading biennial international trade exhibition in Europe covering all aspects of water technology. The tenth **Aquatech** will be staged in the RAI Complex alongside the 12th IAWPRC Biennial International Conference on Water Pollution Control.

In previous years, **Aquatech** has been found to be a unique exhibition for all who are interested in water technology. The high level of interest is partly due to the fact that new developments are often shown for the first time at **Aquatech**.

Aquatech covers the following themes:

- Water abstraction
- Transport and storage of water
- Purification
- Quality Monitoring
- Liquid waste
- Hydrodynamic engineering
- Environmental engineering
- Research and development
- Equipment

Aquatech '82 attracted an attendance totalling 35000 visitors from throughout the world. With 354 exhibitors covering an area of some 40000 square meters, **Aquatech** is the largest specialised water exhibition in the world.

IAWPRC conference participants will receive a free copy of the catalogue and will have free admission to the exhibition throughout the period of **Aquatech** '84.

In your conference bag is a voucher for the Aquatech Exhibition. Delegates can use this voucher to obtain a catalogue of the Aquatech '84 Exhibition free of charge at the Aquatech information desk near the entrance to the RAI Exhibition Centre.

The August edition of World Water, which is included in the conference bag, contains detailed information on the exhibition.

10 Post Conference Seminars

24-25 September 1984 Antwerp Belgium	ADVANCED TREATMENT TECHNOLOGIES FOR REMOVAL AND DISPOSAL OF MICROPOLLUTANTS Removal of trace organics in water; removal by adsorption techniques with activated carbon; removal of trace elements by precipitation and matrix enmeshment; removal of micropollutants as a side effect of desalination; oxidation methods; stability of micropollutants in disposal products of treatment techniques. Organization: F. Rillaerts, Secretary of Belgian National Committee of IAWPRC, Waterloosesteenweg 225, Bus 6, B-1000 Brussels, Belgium. Tel. (02) 5374302.
24-25 September 1984 Paris France	ENHANCED BIOLOGICAL PHOSPHORUS REMOVAL FROM WASTEWATER Microbiology; chemistry and biochemistry; pilot scale studies; full scale studies; treatment, handling and disposal of phosphate rich sludges, research and development needs. Organization: Dr. M. Florentz, Phosphorus Seminar, Anjou Recherche, 52 Rue d'Anjou, 75384 Paris, Cedex 08, France. Tel. 266 91 50.

11 Social Programme

All registered delegates and registered accompanying persons are cordially invited to attend the social functions. All social functions are free of charge.

Sunday 16 September 18h00 - 19h30	**Meet and Greet Reception in the RAI Conference Centre** During registration in the RAI Conference Centre there will be an informal 'Meet and Greet'. After a welcoming address by the Conference President and the President of the IAWPRC, the Director of the Sewerage and Drainage Department of Amsterdam, Ir. M.K.H. Gast, will introduce everyone to Amsterdam.
Monday 17 September 18h30 - 20h00	**Official Reception in the Rijksmuseum in Amsterdam** The official reception is hosted by the Ministry of Traffic and Public Works, the Ministry of Housing, Physical Planning and Environment and the City of Amsterdam. The Rijksmuseum is the most famous museum in the Netherlands, including 1 million objets d'art. The famous painting 'The Night Watch' by Rembrandt, together with 5,000 works of Old Masters are on display.
Wednesday 19 September 19h00 - 1h30	**Amsterdam Night in the Marriott Hotel in Amsterdam** From the RAI all delegates and accompanying persons will travel on special trams through the old city of Amsterdam to the Marriott Hotel at the Stadhouders Kade, (the last tram departing at 19h30) A very attractive programme including an extensive buffet, drinks, music, dancing, entertainments etc. will be presented. Netherlands crafts, roulette, a Greek restaurant and a disco are part of the programme. From 24h00 until 1h30 special buses will return you to the RAI
Thursday 20 September 16h30 - 18h30	**Farewell Cocktail in the RAI Conference Centre** After the final technical sessions there will be a Farewell Cocktail in the area around Hall 1. Information will be given about Friday's Programme of technical excursions and there will be a short look forward to future Biennial Conferences of the IAWPRC in Rio de Janeiro (1986), London (1988) and Tokyo (1990).

All delegates and accompanying persons should wear their badge during the social events.

12 Programme for Accompanying Persons

All registered accompanying persons are entitled to:
- attendance at the Opening Ceremony
- attendance at all the social functions (including transport to Marriott Hotel for the Amsterdam Night).

Reservations and payment for touristic tours should have been made beforehand.
Buses for the touristic tours will depart from the RAI Conference Centre at the times indicated in the following list.
All accompanying persons who have registered for the tours are requested to report to the information desk of the travel agent in the RAI before departure.
They will then be introduced to their Tour Manager and be accompanied to the bus.
Unfortunately the programme of thematic tours has been cancelled due to lack of interest. Only the tour "Education"(*), will be held.

	Touristic Tours	Price (Dfl.)
Sunday 16 September	1a City Tour Amsterdam	31,—
	2a Oudewater, Gouda, Kinderdijk	54,—*
Monday 17 September	1b City tour Amsterdam	31,—
Tuesday 18 September	2b Oudewater, Gouda, Kinderdijk	54,—*
	3 Flowers and costumes tour	58,—*
Wednesday 19 September	4 Westland and Rotterdam	66,—*
	5 The Hague	31,—
	* Education	17,—
Thursday 20 September	6 The Hague and Delft	65,—*
	7 Delta Works	72,—*
Friday 21 September	8 Arnhem	67,—*
	9 Cheese Market	26,—

*luncheon included

13 Registration and Information

Registration for the conference will take place in the RAI Conference Centre at the following times:

Sunday 16 September: 14h00 - 19h30
Monday 17 September: 8h00 - 17h00

Latecomers can register from Tuesday to Thursday from 9h00 - 17h00.
Registration for the programme of accompanying persons will take place in the RAI Conference Centre at the same times.

Members of the Conference Organizing Committee will be happy to assist delegates whenever possible or refer them to those who can assist them.
Members of the Conference Organizing Committee will be wearing red badges.

For information please contact the registration desk

14 General Information

Public Transport

No special buses have been arranged to transport delegates from their hotel to the RAI Conference Centre. Information on the public transport system in Amsterdam (tram and bus) is given in the book "Surprising Amsterdam" on page 22. "Surprising Amsterdam" is included in your conference bag.

Numbers of trams and buses connecting the hotels with the RAI Conference Centre:

- Hotel de l'Europe, Krasnapolsky, Victoria, Caransa, Carlton, Doelen, Amsterdam Centre and Port van Cleve take tram 4.
- Hotels American, Park, Jan Luyken, Museum, Terdam and Trianon take tram 6,7,10 or 3 and change to tram 4.
- Hotel Apollo and Amsterdam Hilton take bus 15.
- Hotel Casa 400 take bus 8 or 15.

Crest Hotel and Novotel are within walking distance of the RAI Conference Centre.

Car Rental

Car rental can be provided by AVIS which is the official car rental contractor.
Delegates wishing to rent a car will be entitled to 20% reduction.

Parking

There are sufficient parking facilities near the RAI.

Lunches and refreshments

Tea and coffee during the technical sessions will be provided free of charge in the area near the registration desk and poster presentations. It is possible to lunch in the restaurant of the RAI or at the small restaurant at the Aquatech Exhibition. The prices of lunch will vary between Dfl. 15,– and Dfl. 30,– per person.

Lunches during the touristic tours (see programme of accompanying persons) are included in the fee for the tour. Lunches during the technical tours on Friday 21 September will be provided free of charge.

First Aid

A first aid service will be available in the registration area.

Banking

During registration banking facilities will be available at the registration desk.

Telephones

Public telephone booths are available in the RAI Conference Centre. The telephone number for incoming calls for IAWPRC is: Amsterdam (020) 420018/ 420139.

Postal facilities

There are post boxes in the concourse of the RAI Centre.

Telex facilities

The telex number to receive and relay telex messages to delegates is the telex address of the RAI Conference Centre 13499.

Interpretation

Simultaneous interpretation services in English, French and German will be provided in Halls 1, 2 and 3 during all technical sessions.

photocopies

It is possible to make photocopies at the offices of the gate-keepers in the RAI. One photocopy will cost Dfl. 0,25.

15 Organization

The conference will be organized under the auspices of the International Association on Water Pollution Research and Control (IAWPRC) in co-operation with the Nederlandse Vereniging voor Afvalwaterbehandeling en Waterkwaliteitsbeheer NVA (Netherlands Association for Wastewater Treatment and Water Pollution Control).

Organizing Committee:

Ir. H. Ehrhardt	- President Organizing Committee and Netherlands National Committee - IAWPRC
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16 Acknowledgements

The following organizations have granted generous sponsorship in varying forms for this conference. Their assistance is gratefully acknowledged by the Conference Organizing Committee and by the Netherlands National Committee of the IAWPRC.
In alphabetical order we thank the following organizations:
City of Amsterdam
Amsterdam Public Works Department
Aquatech Exhibition, Schiedam
Digital Computers, Utrecht
Elma BV, Oudkarspel
Endress & Hauser BV, Bussum
Esmil, Amsterdam
Geveke, Amsterdam
Gist Brocades, Delft
H_2O journal, Rijswijk
Hoechst, Amsterdam
Holthuis Pumps, Venlo
Kamsteeg Contractors, Amsterdam
KLM Airlines, Schiphol
KSB Pumps, Zwanenburg
Ministry of Public Works and Transport, The Hague
Ministry of Housing, Physical Planning and Environment, The Hague
Nashua Photocopiers, Maarssen
Netzsch Filterpresses and Pumps, Selb and Wald Kraiburg, FRG
ONRI Consulting Firms:
  BKH, Consulting Engineers, The Hague
  DHV, Consulting Engineers, Amersfoort
  DSBV, Engineers and Architects, Rotterdam
  Haskoning, Consulting Engineers and Architects, Nijmegen
  Infra-Consult, Consulting Engineers, Deventer
  IWACO, International Water Supply Consultants, Rotterdam
  Mabeg-van Hasselt, Engineers and Architects, Utrecht
  Tebodin, Consulting Engineers, The Hague
  Witteveen + Bos, Consulting Engineers, Deventer
Provincial Water Board of Friesland, Leeuwarden
Rutte Recycling, Halfweg
Water Board of Uitwaterende Sluizen, Edam
WAVIN, Hardenberg

We thank the following hosts for technical visits during the conference:
Amsterdam Public Works Department, Amsterdam
CSM, Sugar Company, Breda
Delft Hydraulics Laboratory, Delft
Deltadienst of the Ministry of Public Works and Transport, The Hague
Drinking Water Supply Company of Biesbosch, Rotterdam
Gist Brocades, Delft
Netherlands Water Works Testing and Research Institute KIWA, Nieuwegein
RIZA, Lelystad
Rijksdienst IJsselmeerpolders, Lelystad
Shell Petroleun Company, Pernis
Water Board of Delfland, Delft
Water Board of Hollandse Eilanden en Waarden, Dordrecht
Water Board of Rijnland, Leiden

17 Amsterdam

Amsterdam is the largest and capital city of The Netherlands, situated at the mouth of the river Amstel. The heart of the old city has been beating since 1275, but three centuries went by before the citizens of Amsterdam could claim to be the most prosperous of Europe. During the 17th century, the Golden Age, the famous canal system was dug around the mediaeval city walls. Along the banks of the three main canals, merchants built richly decorated houses to flaunt their wealth. More than 7,000 historical houses and buildings have been converted, which create a fascinating contrast between the old and the new. Inside the modern cosmopolitan centre you will find the Royal Palace on the Dam, the West Tower and many old churches. Amsterdam ranks fourth in the European tourist centre league, 7% of its annual income comes from tourism. Amsterdam is often called the 'Gateway to Europe', not only because it is an important commercial and industrial centre on the borders of the North Sea, but also because of its rich social and cultural life. Amsterdam is a melting pot of nationalities. The port plays a leading role in the city's economic life: the docks cover 9,200 acres, which is 18% of the city's total area.

Things to see and to do in Amsterdam.

A canal trip is the best way to see the most characteristic part of Amsterdam. In September the canals are lit with thousands of lights. Visiting the 'Rijksmuseum', the Vincent van Gogh Museum, the Historic Museum or the Municipal Museum you will find a great collection of classic and modern art. The house where Rembrandt lived and worked is open to visitors. The traditional craft of diamond cleaving and cutting, together with the diamond trade, makes Amsterdam the city of diamonds. Many diamond polishing factories are pleased to receive visitors. Walking around Amsterdam also means shopping. Exceptional boutiques, fashion shops and many antique shops are situated in a compact area. In any one of the restaurants you can eat in 'any language' you want. Bread rolls filled with cheese, ham, shrimps, eel are the expression of lunchtime in Amsterdam.

Centre of science and cultural life.

Amsterdam possesses two universities with more than 35,000 students. Music has been performed since 1888 in the 'Concertgebouw', famous for its acoustics. The internationally-known Concertgebouw Orchestra, together with the Amsterdam Philharmonic, give regular concerts there. In the Lutheran Church, Sunday morning coffee concerts have become very popular. In Amsterdam you will find no less than 42 historical church organs. The 'Stadsschouwburg' is the home of the Dutch Opera as well as the National Ballet Company.

'Carré', originally built for circus performances in 1887, is today the most famous theatre in Amsterdam, apart from many other theatres and 40 cinemas.

There are many bars, terraces, restaurants and nightclubs, where you can spend the evening.

Amsterdam is a very colourful city, but its greenness makes a most memorable impression.

There are numerous parks, like the famous 'Vondelpark'.

However Amsterdam is a tolerant, swinging city. The best way to discover Amsterdam is to go to a real Amsterdam cafe and take a quiet look around you at the people.

APPENDIX B

Program: Seminar on Freshwater Biological Monitoring, September 12-15, 1984, Cardiff, United Kingdom

IAWPRC - UWIST

SEMINAR ON
FRESHWATER BIOLOGICAL MONITORING

September 12-15th 1984
at

The Department of Applied Biology, University of Wales Institute of Science and Technology, Cardiff, U.K.

as part of the 12th IAWPRC Biennial International Conference on Water Pollution

WEDNESDAY 12th	all lectures will be in Room 157
16.30	For those resident at Traherne Hall, coach departs from Traherne for UWIST Redwood Building.
16.45 - 17.45	Registration in the Redwood Building, UWIST, Cathays Park.
18.00	Introductory remarks and welcome by Mr L. E. Taylor, Head of Water and Environmental Protection Division, Welsh Office and Chairman of the Organizing Committee.
18.05	John Cairns Jr University Distinguished Professor and Director, Virginia Polytechnic Institute and State University, U.S.A. gives the Keynote Address on: FRESHWATER BIOLOGICAL MONITORING
19.00	Coach leaves Redwood Building for Cardiff Castle.
	Reception and Conference Dinner in the Banqueting Hall of Cardiff Castle with guests the Baroness White of Rhymney, Chairman of UWIST Council and Mr John Jones, Chairman of the Welsh Water Authority.
22.00	Coach leaves Cardiff Castle for Traherne Hall.
THURSDAY 13th	
09.10	Coach departs Traherne Hall for UWIST, Redwood Building.
SESSION I	Chairman Dr. J. Hellawell, Severn Trent Water Authority, U.K.
9.30	Mr H. A. HAWKES and Mr A. J. WATTON (University of Aston, U.K.): The performance of an invertebrate colonization sampler (S. Auf. U) in biological surveillance of lowland rivers.

10.00 Dr N. De PAUW, Dr D. ROELS and Dr P. FONTOURA (State University of Ghent, Belgium):

Use of artificial substrates for standardized sampling of macroinvertebrates in the assessment of water quality by means of the Belgian Biotic Index.

10.30 COFFEE

11.00 Dr. M. P. BROOKER (Welsh Water Authority, U.K.):

Biological surveillance in Welsh rivers for water quality and conservation assessment.

11.30 Dr. J. F. WRIGHT,(Freshwater Biological Association, U.K.)

Classification of running-water sites using macroinvertebrates and recent attempts to predict species from environmental data.

12.00 Dr F. M. CHUTTER (National Institute for Water Research, South Africa):

Invertebrate drift in the biological monitoring of water quality.

LUNCH

SESSION II Chairman Dr S. Warren, Director, Environmental Protection, Water Research Centre U.K.

14.00 Dr. P. HEINONEN, read by Mr T. KOHONEN (National Board of Waters, Finland):

Early warning of eutrophication in rivers by analysis of periphyton chlorophyll a

14.30 Dr F. VAN HOOF, Dr W. VAN CRAENENBROECK and Dr MARIVOET (Antwerp, Belgium):

Investigations into the causes of fishkills occurring in the River Meuse (1979-1983)

15.00 Professor R. W. EDWARDS (UWIST and Welsh Water Authority, (U.K.):

Assessing the recovery of two coalfield rivers : the relationship between biology and water quality.

15.30 TEA

16.00 Dr W. S. G. MORGAN and Mr P. C. KÜHN (National Institute for Water Research, South Africa):

Aspects of utilizing continuous automatic fish biomonitoring systems for industrial effluent control.

16.30	Dr E. L. MORGAN, Dr R. C. YOUNG and Dr C. M. CRANE (Tennessee Technological University, U.S.A.): Automated multispecies biomonitoring employing fish and aquatic invertebrates of various trophic levels.
17.15	Coach departs for Traherne Hall
20.00	Coach returns to Redwood Building
20.15	Reception and poster session
22.00	Coach departs for Traherne Hall.
FRIDAY 14th	
09.10	Coach departs Traherne Hall for UWIST Redwood Building.
SESSION III	Chairman Professor J. Cairns Jr, Virginia Polytechnic Institute and State University, U.S.A.
09.30	Dr K. WILLIAMS, Dr D. GREEN and Dr D. PASCOE (UWIST, U.K.): Toxicity testing with freshwater macroinvertebrates. Methods and application in environmental management.
10.00	Dr J. F. SKIDMORE and Dr I. C. FIRTH (New South Wales Institute of Technology, Australia): Prediction of the toxicity of copper to Australian freshwater animals.
10.30	COFFEE
11.00	Mr N. O. CROSSLAND (Shell Research Ltd., U.K.): Fate and effects of Chemicals in outdoor ponds compared with predictions based on laboratory tests.
11.30	Major T. R. DOANE, Professor J. CAIRNS Jr, Dr. A. L. BUIKEMA (Virginia Polytechnic Institute and State University, U.S.A.) Comparison of biomonitoring techniques for evaluating effects of jet fuel on bluegill sunfish (*Lepomis macrochirus*)
12.00	Professor P. CALOW (University of Sheffield, U.K.) Intraspecific variability to stress tolerance : implications for toxicity testing.
	LUNCH
SESSION IV	Chairman Dr. H. A. M. de Kruijf, National Institute for Public Health and Environmental Hygiene, The Netherlands.
14.00	Dr Y. NASU, Dr M. KUGIMOTO, Dr. O. TANAKA and Dr A. TAKIMOTO, (Shinshu University, Japan): *Lemna* as an indicator of water pollution and the absorption of heavy metals.

14.30	Dr T. KÄLLQVIST (Norwegian Institute for Water Research, Norway): The application of an algal assay to assess toxicity and eutrophication in polluted streams.
15.00	Mr P. WILCOX and Mr H. HORTH (Water Research Centre U.K.): Microbial mutagenicity testing of water samples.
15.30	TEA
16.00	Dr S. MATSUI (Kanazawa University, Japan): The Bacillus subtilis microsome rec-assay for the detection of presence of mutagens in waters of a municipal wastewater treatment plant.
16.30	Dr E. E. HERRICKS and Dr D.J. SCHAEFFER (University of Illinois at Urbana - Champaign, U.S.A.): Compliance biomonitoring - standard development and regulation enforcement using biomonitoring data.
17.00	PROFESSOR R. J. H. BEVERTON - Concluding remarks
17.30	Coach departs for Traherne Hall.
Evening	Theatre

SATURDAY 15th

Tour of rivers reservoirs and water treatment works in South Wales, together with a visit to the Welsh Water Authority Headquarters in the Brecon Beacons National Park, where lunch will be provided.

09.00	Coach departs UWIST Redwood Building
09.10	Coach departs Traherne Hall
15.00	Coach arrives back in Cardiff.

Those travelling on to the main conference in Amsterdam may find the following information useful:

> There are no flights to Amsterdam from Cardiff on Saturday or Sunday and so it will be necessary to depart from London (Heathrow). The tour should finish in time for you to take the 15.25 train from Cardiff arriving Heathrow at 18.10 to catch the 19.30 flight arriving Amsterdam 21.30. Alternatively if you take a later train from Cardiff and stay in London overnight, the 10.15 Sunday flight arrives Amsterdam at 12.15. The current flight cost is £66 (Eurobudget) or £78 (Clubclass).

POSTER PRESENTATIONS

DR H. A. M. de KRUIJF (The Netherlands)

Biomonitoring in the Netherlands

MR R. A. MILNE (U.K.)

The Loughor Estuary: an approach to Environmental quality control

MR P. LOGAN (U.K.)

A biological Assessment of the River Plym

DR M. A. LEARNER (UWIST, U.K.)

The macroinvertebrate fauna of the River Ely

MR D. G. HOLLAND (U.K.)

The use of biological data for river water quality classification

MR R. B. E. SHUTES (U.K.)

A comparison of the benthic macroinvertebrate fauna of two North London streams

MR S. ORMEROD (UWIST, U.K.)

Assemblages of benthic macroinvertebrates in the catchment of the River Wye in relation to environmental factors

PROFESSOR R. W. EDWARDS (UWIST, U.K.)

The River Wye Catchment and Craig Goch reservoir scheme

MR C. R. DOUGHTY (U.K.)

Monitoring acid waters in Western Scotland

DR J. H. STONER (U.K.)

Acidification in Wales

DR R. WILLIAMS (UWIST, U.K.)

Recovery of the River Ebbw

MR G. W. MAWLE (UWIST, U.K.)

Recovery of the River Taff

PROFESSOR R. W. EDWARDS (UWIST, U.K.)

The Monmouthshire levels drainage system

DR G. P. EVANS (U.K.)

Mobile intake protection systems (MIPS)

DR. G. P. EVANS (U.K.)

Detection of acute pollution at drinking water intakes.

DR P. WEIS (U.S.A.)

Utility of fin regeneration in testing sublethal effects of pollutants

DR D. PASCOE (UWIST, U.K.)

Toxicity testing with fish eggs and juveniles.

DR S. J. TYLER (U.K.)

Dippers (*Cinclus cinclus* : Aves) as indicators of surface water acidity in upland Wales

DR. C. J. VAN LEEUWEN (The Netherlands)

Differences in the susceptibility of early life stages of rainbow trout to environmental pollutants

DR. C. J. VAN LEEUWEN (The Netherlands)

Population toxicity studies with *Daphnia magna*.

DR. M. P. BROOKER (U.K.)

Wildlife in River Corridors.

Program: Seminar on Advanced Treatment Technologies for Removal and Disposal of Micropollutants, September 24-25, 1984, Antwerp, Belgium

Post Conference Seminar

ADVANCED TREATMENT TECHNOLOGIES FOR REMOVAL AND DISPOSAL OF MICROPOLLUTANTS

organized by the Belgian I.A.W.P.R.C. Committee

PROGRAMME

Monday 24th September 1984 - Afternoon

01.00 p.m.	Registration
02.00 p.m.	1. Presidential address by Prof. ir. A. VAN HAUTE (Belgium)
02.15 p.m.	2. Removal of traces of arsenic and selenium by activated alumina M. GHOSH, J.R. JUAN, R. SCHLICHER and S.M. HORNUNG (U.S.A.)
03.00 p.m.	3. Two options for treatment of acidic organic industrial wastes N. MILLOT, N. DALGA and N. FOUSSARD (France)
03.45 p.m.	Coffee-break
04.15 p.m.	4. Heavy metal removal in the presence of colloid-stabilizing organic material and complexing agents I. LICSKÓ and I. TAKÁCS (Hungary)
05.00 p.m.	Closing

Tuesday 25th September 1984 - Morning

09.15 a.m.	5. Changes in particle size distributions on a fixed bed of granular activated carbon E.A. SHPIkT and K.T. ALBEN (U.S.A.)
10.00 a.m.	6. Treatment of tar sand wastewaters with activated carbon, ozone and reverse osmosis R.A. SIERKA and P.H. KING (U.S.A.)
10.45 a.m.	Coffee-break
11.15 a.m.	7. Water treatment by means of activated carbon, prepared from locally available waste materials (II) H. KEIRSSE, F. VAN HOOF, J. JANSSENS and A. BUEKENS (Belgium)
12.00 a.m.	Lunch

Tuesday 25th September 1984 - Afternoon

01.30 p.m.	8. Elimination of micropollutants by $NaAlO_2$ flocculation during primary treatment of mixed wastewater Messrs. VANDERBORGHT and WOLLAST (Belgium)
02.15 p.m.	9. Upgrading of a wastewater treatment plant in a chemical factory P. BENEDEK, I. TAKÁCS and I. VALLAI (Hungary)
03.00 p.m.	Coffee-break
03.30 p.m.	10. Impact of selected pretreatments on the quantity and distribution of organic halide precursors D. RECKHOW (U.S.A.)
04.15 p.m.	Open forum Conclusions by Dr. W. MASSCHELEIN, Chairman of the Scientific Committee (Belgium)

I.A.W.P.R.C.

POST CONFERENCE SEMINAR on ADVANCED TREATMENT TECHNOLOGIES FOR REMOVAL AND DISPOSAL OF MICROPOLLUTANTS

ANTWERP 24-25-09-1984

LIST OF PARTICIPANTS

Messrs		
1. A.VAN HAUTE	*University LEUVEN*	*Belgium*
2. M.M.GHOSH	*PENN.State University*	*U.S.A.*
3. N.MILLOT	*Société Lyonnaise des Eaux et de l'Electricité*	*France*
4. M.SHPIRT	*NEW YORK State Department of Environmetal Concertation*	*U.S.A.*
5. E.SHPIRT	*NEW YORK State Department of Health*	*U.S.A.*
6. R.SIERKA	*University of ARIZONA*	*U.S.A.*
7. H.KEIRSSE	*Study Centre for Water BRUSSELS*	*Belgium*
8. R.WOLLAST	*University of BRUSSELS*	*Belgium*
9. I.TAKACS	*Research Centre Vituki*	*Hungary*
10. J.DIRICKX	*ANTWERP Waterworks*	*Belgium*
11. W.MASSCHELEIN	*BRUSSELS Water Supply*	*Belgium*
12.Mr.FRIPIAT	*Hydrocontrol*	*Belgium*
13. R.SAVOIR	*BRUSSELS Water Supply*	*Belgium*
14. J.HIEMELEERS	*Metallurgie Hoboken-Overpelt*	*Belgium*
15. B.KHUDENKO	*Technical School of Civil Engineering ATLANTA*	*U.S.A.*
16. P.KING	*University of ARIZONA*	*U.S.A.*
17. H.POLS	*RIZA -LELYSTAD*	*The Netherlands*
18. F.VAN HOOF	*ANTWERP Waterworks*	*Belgium*
19. J.JANSSENS	*ANTWERP Waterworks*	*Belgium*
20. A.BLANCKAERT	*Procter and Gamble Benelux*	*Belgium*
21. B.VAN VLIET	*Nat.Institute for Water Res.PRETORIA*	*South Africa*
22. H.ALBERS	*Institut für Stadtbauwesen - BRAUNSCHWEIG*	*West-Germany*
23. G.BOVEN	*Tessenderlo Chemie*	*Belgium*
24. F.C.VILJOEN	*Rand Water Board - JOHANNESBURG*	*South-Africa*
25. P.FRONEMAN	*Keeve Steyn and Partners Inc.- BRAAMFONTEYN*	*South-Africa*

26. B.BECKERS	*LISEC-Studiecentrum Ecologie/Bosbouw GENK*	*Belgium*
27. R.VERHOEF	*Zuiveringschap Amstel en Gooiland HILVERSUM*	*The Netherlands*
28. L.WILMOTTE	*A.I.D.E. TILLEUR*	*Belgium*
29. A.GUIRAUD	*S.E.T.U.D.E. - PARIS*	*France*
30. S.BEERNAERT	*G.O.M. West-Vlaanderen BRUGGE*	*Belgium*
31. F.VAN DEN BOSSCHE	*Vlaamse WaterzuiveringsMij AALST*	*Belgium*
32. J.VAN DER SCHROEFF	*GrontMij - DE BILT*	*The Netherlands*
33. P.PISCAER	*idem*	*idem*
34. P.M.WILLIS	*Johnson Matthey Research Centre-Reading*	*United Kingdom*
35. J.BULTYNCK	*WaterzuiveringsMij v.h.Kustbekken OOSTENDE*	*Belgium*
36. D.RECKHOW	*Compagnie Générale des Eaux (F)*	*U.S.A.*

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APPENDIX C

Memorandum: "Development of Report for E.P.A. on IAWPRC Amsterdam Conference," August 1, 1984

IAWPRC

UNITED STATES OF AMERICA NATIONAL COMMITTEE
FOR REPRESENTATION OF THE UNITED STATES TO THE
INTERNATIONAL ASSOCIATION ON WATER POLLUTION RESEARCH & CONTROL

CHAIRMAN:
DR. FRED G. POHLAND (AEEP)
SCHOOL OF CIVIL ENGINEERING
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332
(404) 894-2265

VICE-CHAIRMAN:
DR. RICHARD S. ENGELBRECHT (WPCF)
3230 CIVIL ENGINEERING BLDG.
UNIV. OF ILLINOIS @ URBANA-CHAMPAIGN
208 NORTH ROMINE STREET
URBANA, ILLINOIS 61801
(217) 333-3822

SECRETARY-TREASURER:
MR. RICHARD A. CONWAY (ASCE)
RESEARCH & DEVELOPMENT DEPARTMENT
UNION CARBIDE CORPORATION
P. O. BOX 8361 (770-342)
SOUTH CHARLESTON, WEST VIRGINIA 25303
(304) 747-4016

August 1, 1984

TO:

FROM: F. G. Pohland, USANC Chairman Fred Pohland

RE: Development of Report for EPA on IAWPRC Amsterdam Conference

I have been informed by the London Office of IAWPRC that you have been invited to participate in the IAWPRC International Conference at Amsterdam, September 17 through 21, 1984 in the following capacity:

As a result, I am assuming that you will be in attendance at this conference.

Under separate grants from EPA, USANC has prepared reports on the developments of the Sydney (1976), Stockholm (1978), Toronto (1980) and Cape Town (1982) IAWPRC International Conferences. In each case, U. S. participants in the respective conferences contributed to the report. It is intended that a similar type report be prepared for EPA on the Amsterdam Conference under a grant from EPA. The purpose of this letter is to assess your interest in participating in this USANC activity as a contributor to the report. Fifty (50) U.S. participants in the Amsterdam Conference have been identified; however, only about twenty five (25) can be accommodated as contributors to the report and receive financial reimbursement from the EPA grant.

The report will be an interpretive analysis of the formal and informal happenings and developments at the Conference, not just a collection of papers or abstracts. Rather, the report is to be a critical assessment of the merit of the different presentations at the Conference, together with an evaluation of the floor discussion associated with each presentation. Information gathered informally having relevance to global water pollution research and control developments will also be included in the report.

Contributors to the report will be responsible for intensively covering some assigned portion of the Conference. This will involve not only attendance at an assigned session and critique of a group of poster presentations, but informal conversations with authors and other Conference participants so as to develop unique insights beyond the content of the formal proceedings. Contributors to the report should also be alert to developments of a research nature outside of the technical or poster sessions of the Conference. Shortly after the Conference, each contributor will submit a concise (typically 6 to 10 typed pages) report covering the pertinent developments at his/her assigned sessions and any other pertinent observations made at the Conference. If you are selected to contribute to the report, more specific information on the intended nature of the overall report and on individual report requirements will be provided to you before the Conference.

Contributors to the report will be reimbursed for some of their expenses and services. It should be pointed out that the purpose of the EPA grant to USANC is to prepare the report outlines above, it is not a travel grant. In fact, reimbursement for international travel, i.e., that portion of your travel to Amsterdam and return to the U.S. will not be allowed. However, contributors will be reimbursed for a portion of their services. The eventual amount of reimbursement will depend on the number of contributors and the funds available, but should be adequate to cover a portion of the expenses associated with attending the Conference.

Please complete and return the enclosed form, indicating your interest in contributing to the proposed report and the technical or poster session to which you would like to be assigned. In the interest of objectivity, please do not select sessions in which you are a participant. A copy of the Amsterdam Conference program and listing of poster sessions is attached.

This memorandum is being sent to only one author per paper or poster. In the case of multiple authorship, this mailing is being forwarded to the author who I presume will be making the presentation at Amsterdam. It is necessary, because of limited funds, to solicit only one author per paper as a potential contributor to the report.

If I do not hear from you by August 20, 1984, I shall assume that you are not interested in participating in the preparation of the report. If you have any question, please telephone me at (404) 894-2265.

hb
Attachments

P.S. For those of you who have not made hotel reservations in Amsterdam, space is rapidly being depleted and immediate attention to this matter is encouraged.

Questionnaire

Concerning Participation in Preparation of
Proposed USANC Report for EPA on

DEVELOPMENTS AT TWELFTH INTERNATIONAL CONVERENCE ON WATER POLLUTION RESEARCH AND CONTROL

Amsterdam, The Netherlands

September 17-21, 1984

1. I shall be a participant in the IAWPRC Conference in Amsterdam in the following capacity(ies):

_____Presenting Paper or Poster Number_____.

_____Invited Discusser of Paper Number_____.

_____Chairman of Session _____ on _______________ at _______________.
Hall date time

_____Recorder of Session _____ on _______________ at _______________.
Hall date time

2. I (do) (do not) wish to participate in developing the proposed report to EPA. Indicate amount of partial support requested: $____________

3. If you wish to participate in developing the proposed report to EPA, complete the next page relative to the session you are interested in covering.

4. Name ____

Mailing Address ____

____

____

____

Phone ____________________

Date ____________________

____
Signature

PLEASE COMPLETE AND MAIL SO AS TO REACH:

F. G. Pohland
School of Civil Engineering
Georgia Institue of Technology
Atlanta, Georgia 30332

USANC; 12th IAWPRC CONFERENCE

____
Name

5. Indicate the formal sessions of most interest to you by priority, i.e., 1, 2, and

Priority **Session**

MONDAY, 17 SEPTEMBER

Priority		Session	
____	Hall 1,	2:00 pm - 5:25 pm	(Papers Nos. 1,2,3,4,5)
____	Hall 2,	2:00 pm - 5:25 pm	(Papers Nos. 35,36,37,38,39)
____	Hall 3,	2:00 pm - 5:25 pm	(Papers Nos. 69,70,71,72,73)

TUESDAY, 18 SEPTEMBER

Priority		Session	
____	Hall 1,	9:00 am - 12:15 pm	(Papers Nos. 6,7,8,9,10)
____	Hall 2,	9:00 am - 12:25 pm	(Papers Nos. 40,41,42,43,44)
____	Hall 3,	9:00 am - 12:25 pm	(Papers Nos. 74,75,76,77,78)
____	Hall 1,	2:00 pm - 5:25 pm	(Papers Nos. 11,12,13,14,15)
____	Hall 2,	2:00 pm - 5:25 pm	(Papers Nos. 45,46,47,48,49)
____	Hall 3,	2:00 pm - 5:25 pm	(Papers Nos. 79,80,81,82,83)

WEDNESDAY, 19 SEPTEMBER

Priority		Session	
____	Hall 1,	9:00 am - 12:25 pm	(Papers Nos. 16,17,18,19,20)
____	Hall 2,	9:00 am - 12:25 pm	(Papers Nos. 50,51,52,53,54)
____	Hall 3,	9:00 am - 12:25 pm	(Papers Nos. 84,85,86,87,88)
____	Hall 1,	2:00 pm - 5:25 pm	(Papers Nos. 21,22,23,24,25)
____	Hall 2,	2:00 pm - 5:25 pm	(Papers Nos. 55,56,57,58,59)
____	Hall 3,	2:00 pm - 5:25 pm	(Papers Nos. 89,90,91,92,93)

THURSDAY, 20 SEPTEMBER

Priority		Session	
____	Hall 1,	9:00 am - 12:25 pm	(Papers Nos. 26,27,28,29,30)
____	Hall 2,	9:00 am - 12:25 pm	(Papers Nos. 60,61,62,63,64)
____	Hall 3,	9:00 am - 12:25 pm	(Papers Nos. 94,95,96,97,98)
____	Hall 1,	2:00 pm - 4:20 pm	(Papers Nos. 31,32,33,34)
____	Hall 2,	2:00 pm - 4:20 pm	(Papers Nos. 65,66,67,68)
____	Hall 3,	2:00 pm - 4:20 pm	(Papers Nos. 99,100,101,102)

6. Indicate the poster sessions of most interest to you by order of priority; i.e., 1,2,3,4 and 5

Priority	Poster Session
1	____
2	____
3	____
4	____

Memorandum: "Assignments for Development of
USANC Report on Amsterdam Conference,
September 17-21, 1984," August 28, 1984

IAWPRC

UNITED STATES OF AMERICA NATIONAL COMMITTEE
FOR REPRESENTATION OF THE UNITED STATES TO THE
INTERNATIONAL ASSOCIATION ON WATER POLLUTION RESEARCH & CONTROL

CHAIRMAN:
DR. FRED G. POHLAND (AEEP)
SCHOOL OF CIVIL ENGINEERING
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332
(404) 894-2265

VICE-CHAIRMAN:
DR. RICHARD S. ENGELBRECHT (WPCF)
3230 CIVIL ENGINEERING BLDG.
UNIV. OF ILLINOIS @ URBANA-CHAMPAIGN
208 NORTH ROMINE STREET
URBANA, ILLINOIS 61801
(217) 333-3822

SECRETARY-TREASURER:
MR. RICHARD A. CONWAY (ASCE)
RESEARCH & DEVELOPMENT DEPARTMENT
UNION CARBIDE CORPORATION
P. O. BOX 8361 (770-342)
SOUTH CHARLESTON, WEST VIRGINIA 25303
(304) 747-4016

MEMORANDUM

DATE: August 28, 1984

TO:

FROM: F. G. Pohland, Chairman Fred Pohland

SUBJECT: Assignments for Development of USANC Report on Amsterdam Conference; September 17-21, 1984

The Coordinating Subcommittee for preparing USANC's analysis of developments at the IAWPRC Conference in Amsterdam has assigned sessions to be covered by participants in the project. Your assignment is to prepare a penetrating interpretive analysis of developments at the following:

Formal Sessions:

Date ____________________

Hall ____________________

Time ____________________

Poster Presentations:

The Subcommittee has attempted to accommodate the expressed preferences of the participants for particular sessions whenever possible; the indicated assignments reflect this procedure.

It is essential that you contact one of the members of the USANC Coordinating Subcommittee soon after you arrive in Amsterdam. The purpose is to verify your presence and to learn of any problems which may have developed.

The members of the Subcommittee are:

Frederick G. Pohland
Richard S. Engelbrecht
Richard A. Conway

Guidelines for preparation of individual reports are enclosed. Inasmuch as each individual's report will appear in the overall project report, it is essential that the guidelines be followed closely. Note particularly the deadline (January 7, 1985) for submission of reports; to achieve maximum value, the report must be submitted soon after the Conference.

It is emphasized that each individual's report is to be an interpretive analysis of developments at the Conference. Proceedings, including discussions, will be published by IAWPRC, and these will serve as an objective record of the technical details presented at the Conference. Therefore, your report should not include the detailed information that will be otherwise contained in the Conference Proceedings. What is needed for the USANC report is an interpretive assessment of the significance of the presentations and information related to the presentations which will not be found in the Conference Proceedings. Such information might, for example, come from personal discussions with authors or contributors to discussions or poster presentations. (For those of you who have participated in the preparation of our prior reports, please note that the outline for individual reports has been modified.)

In addition to coverage of the assigned session, participants are specifically requested to report pertinent developments at the Conference which do not occur during the formal presentations (see Section VI of the outline for individual reports). The information requested here should arise from personal discussions with colleagues and field trips taken in conjunction with the conference and pre- and post-conference excursions. Enclosed is the entire section of the 1982 Conference report whch concerned developments outside of the technical or poster sessions. Please review this to gain an idea of the type of information desired. It is felt that this section is usually important and provides a unique flavor to this series of USANC reports. It is hoped that this section of the report on the Amsterdam Conference can be expanded over that for our previous efforts. Remember, information presented during the poster sessions probably will not be published intact and, therefore, requires special attention and coverage.

Information on compensation for services and expenses is included in the guidelines. Experience with previous reports has required implementation of rigid financial motivations for submission of reports prior to the deadline; please note the deadline for submission of reports. You should also be aware that the Internal Revenue Service has regulations on deducting personal expenses for attending foreign conferences; this information can be obtained from IRS.

GUIDELINES
for

PREPARATION OF INDIVIDUAL REPORTS

on

DEVELOPMENTS AT THE TWELFTH INTERNATIONAL CONFERENCE
ON WATER POLLUTION RESEARCH AND CONTROL

AMSTERDAM, THE NETHERLANDS

September 17-21, 1984

Emphasis of Report

USANC's report on developments at the IAWPRC Conference in Amsterdam is not intended to be simply a record of the Conference. Instead, an interpretive analysis of significant developments at the Conference is required. This penetrating assessment is to be developed not only by critical analysis of papers and formal and informal discussions at the technical and poster sessions, but also by inclusion of insights gained through more informal contacts with Conference participants. (An example of an individual report from the Cape Town Conference is enclosed as Attachment I to indicate an acceptable interpretive style.)

The positive aspects of Confrence developments should be emphasized (what did you learn that is important to United States water pollution research and control activities?). Don't dwell on criticism of papers which you feel to be inferior, and don't give much space to papers which are not pertinent to problems in the United States. Don't include information of limited significance such as how many people attended a session, how well the session chairman performed, etc.

Distribution

The report will be distributed at least within EPA, to USANC Sponsoring Organizations and USANC committee members, and to participants in the report development. The report also will be made available for consideration as a publication of the National Technical Information Service; its eventual availability will be announced through notices in publications of USANC's Sponsoring Organizations.

Length

Individual reports on sessions are to be as short or long as necessary to adequately describe pertinent developments. It is not necessary to give equal attention to each paper or poster. Space in the report should be allocated on the basis of relevance to U. S. water pollution control problems and water pollution research activities. It is anticipated that the average length of individual reports will be a tightly written 6 to 10 double-spaced pages, but don't unnecessarily expand or condense a concise, penetrating report merely to achieve that length.

Format

The organization and content of the individual reports is to be as indicated in the outline included as Attachment II. Note that the last section of the report provides an opportunity to record observations which do not relate to your assignment and that it should begin on a separate sheet of paper. These contributions from all participants will be combined.

Metric units should be used, and the editorial standards for Water Research (included as Attachment III) should be observed.

Arrangements have been made to record the English translation of each technical session; thus, it will be possible to provide cassette tapes of assigned sessions. These tapes should be obtained after the completion of your assigned session.

Submission

Individual reports are to submitted in double-spaced typed finished form. Four copies of the report are to be postmarked no later than January 7, 1985 and addressed to:

Dr. F. G. Pohland
School of Civil Engineering
Georgia Institute of Technology
Atlanta, GA 30332

Prompt submission of reports is essential. Reports which do not follow the guidelines will be returned for revision and must be submitted in an acceptable form by the January 7, 1985 deadline. As indicated in the following section, reimbursement for late reports will be at a reduced level and no reimbursement will be made for reports postmarked after January 21, 1985.

Compensation

Compensation will require a submitted statement for services and expenses and, as stated above, reimbursement will be contingent upon postmarking of an acceptable report prior to the deadline. No reimbursement for international travel can be allowed. A maximum level of reimbursement will be established based on available funds, cost-sharing requirements, and demands on available funds. Furthermore, because the maximum allowable level of compensation will depend on the magnitude of the total requests for compensation, no payments can be made until all reports are approved (one late individual could hold up all payments). Requests for reimbursement are to be sent to the USANC Secretary-Treasurer, Richard A. Conway, Union Carbide Corporation, P. O. Box 8361 (770-342), South Charleston, WV 25303. Use the expense voucher included as Attachment IV for this purpose.

Reimbursement for acceptable final reports postmarked after January 7, 1985, will be reduced by 50 percent. No reimbursement will be made for reports postmarked after January 21, 1985.

Coordinating Subcommittee

Development of these guidelines, review and acceptance of individual reports and preparation of the final EPA report is being coordinated by a USA National Committee Coordinating Subcommittee consisting of:

Frederick G. Pohland
School of Civil Engineering
Georgia Institute of Technology
Atlanta, GA 30332
Phone: (404)894-2265

Richard S. Engelbrecht
Department of Civil Engineering
University of Illinois
Urbana, IL 61801
Phone: (217)322-3822

Richard A. Conway
Union Carbide Corporation
P. O. Box 8361 (770-341)
South Charleston, WV 25303
Phone: (304)747-4016

Additional information concerning this USANC activity may be obtained from any of the Subcommittee members.

ATTACHMENT I

I. SESSION

A. Day: Thursday, April 1, 1982
Hall: B
Time: 9:00 a.m. to 1:00 p.m.

B. Theme of Session: Physical/Chemical Waste Treatment and Metal Removal

II. REVIEWER

A. Name: David Jenkins

B. Position and Affiliation: Professor of Sanitary Engineering
University of California
Berkeley, CA

III. DESCRIPTION OF SESSION PAPERS

A. Paper No. 33: "Granular Activated Carbon and Preozonated Granular Activated Carbon Treatment for Biologically and Physically-Chemically Treated Wastewater Effluents," by A. Netzer and J. L. McNutt (U.S.A.)

This paper described pilot-plant testing of activated carbon column treatment of both biologically treated, physical-chemical treated and mixed biologically plus physical-chemical treated effluents. Results with and without preozonation of effluents were presented. Improved treatment efficiency and extended carbon life were obtained for preozonated effluents. Much more data (additional parameters and extended periods of performance) were presented. The author indicated that optimization of column loading and ozone dose were being investigated currently.

In the realm of activated carbon studies, this paper could be classified as applied research that investigated the effect of a pretreatment step on performance in terms of gross parameters such as BOD, COD and TOC. It was pointed out that for all these parameters, the prototype plant performed significantly better than the pilot plant (e.g., BOD removal: pilot plant 39%, prototype plant 31-66%; COD removal: pilot plant 25%, prototype plant 43-63%). These significant differences raised questions as to the true similitude between the pilot plant and the prototype designs. The effluents treated by carbon were very high in suspended solids (SS) due to the poor performance of the prototype treatment plants. Discussions raised the question of the effect of SS on the experiments. While no specific response was given, the author noted that initially the carbon columns were backwashed with air scour four times daily. Later, sand filtration was used prior to the carbon

ATTACHMENT II

OUTLINE FOR INDIVIDUAL REPORTS ON DEVELOPMENTS AT AMSTERDAM IAWPRC CONFERENCE

*I. SESSION

  *A. Day, Hall, Time

  *B. Theme of Session (a few words describing the major orientation of papers - e.g., "Marine Disposal" or "Sludge Thickening and Dewatering")

*II. REVIEWER

  *A. Name

  *B. Position and Affiliation

*III. DESCRIPTION OF SESSION PAPERS OR POSTERS

(Paper-by-paper summary, starting with identification, author's or reviewer's abstract, followed by highlights of the formal presentations, prepared discussions and floor discussions. For poster papers, use same format but include as a separate report.)

*IV. CRITIQUE OF SESSION

(Observations and commentary regarding the session and its papers including insights developed outside of the meeting room, possible sources of additional information, and critical review of the papers and the session, indicating matters such as how the research reports were received, their originality and quality, etc.)

*V. SIGNIFICANCE AND VALUE TO AMERICAN WATER POLLUTION RESEARCH ACTIVITIES

(How might the reported results be applied to solve U.S. water pollution problems? What research pertinent to U.S. needs is suggested by the reported research?)

*VI. INFORMATION AND OBSERVATIONS FROM THE CONFERENCE RELEVANT TO U.S. WATER POLLUTION RESEARCH BUT UNRELATED TO ASSIGNED SESSION

(For example, information on water pollution-related developments which was not presented at any of the formal sessions at the Conference, information on emerging problems or on research-in-progress which may be of particular importance.)

NOTE: Section VI will be separated from the remainder of the individual reports - begin on a separate sheet which includes your name.

---

*These headings are to be contained in each report.

ATTACHMENT III

SCRIPT REQUIREMENTS

1. *Typescript*

It should be an original copy, typed in double spacing. It should be submitted, together with four copies, complete with tables and diagrams. The text must be carefully checked so that it is ready for printing. A charge may be made to authors for substantial changes made to proofs other than typographical corrections. Words normally italicized should be typed in italics or underlined.

2. *Illustrations*

Half-tone illustrations should be kept to a minimum. Photographs should be on glossy, not matt, paper and enlarged sufficiently to permit clear reproduction in half tone. All photographs and illustrations must accompany the manuscript, preferably mounted on separate sheets with the author's name and the title of the paper on the back of each photograph or sheet. If words or numbers appear on the photographs, two copies are required, one clearly printed and the other without inscription.

3. *Graphs*

These should be drawn carefully with bold lines and be no larger than necessary. Ordinates, legends, lettering and curves should not extend appreciably beyond points most distant from the point of origin.

4. *Line Drawings*

If these are well drawn and compact in size, they may be reproduced without reduction in size direct from the original, provided original drawings or good photographs are submitted. It is not possible to obtain direct reproduction from "dyeline" prints or from prints with twice the final size, i.e. each dimension should be one third larger than the required printed size. Illustrations should be provided with descriptive legends on a separate sheet and should accompany the manuscript.

5. *Tables*

(a) These should be arranged to conform with those appearing in *Water Research* (but see Item 6 below on space economy).
(b) Type should be clear and even, using an electric typewriter with carbon ribbon.
(c) Tables, headings and legends should be typed on a separate sheet.
(d) Lines on tables should be inserted.
(e) Words normally italicized should be typed in italics or underlined.
(f) Tables will be reproduced by offset means, directly from authors' manuscripts.

6. *Space Economy*

Tables and diagrams should be prepared in a compact form so that they can, if possible, be shown vertically or occupy the width of one column.

7. *References*

References to published literature should be quoted in the text as follows:

> Smith (1950)—The date of publication in parentheses after the author's name.

References should be listed together at the end of each paper and must not be given as footnotes. They should be listed alphabetically starting with the surname of the first author, followed by the title of the referenced paper and the name of the periodical abbreviated in the style of the *World List of Scientific Periodicals* (4th Edition, Butterworths, London, 1963–1965, 3 vols) and appear as follows:

> Fermi E. and Marshall L. (1947) On the interaction between neutrons and electrons. *Phys. Rev.* 72, 1139–1146.

It is particularly requested that (a) Authors initials, (b) the title of the paper and (c) the volume and the page numbers beginning and end are given for each reference.

The abbreviation *et al.* may be used in the text. However, the names of all authors should be given in the list of references.

8. *Abbreviations, Symbols, Synonyms and Nomenclature*

(a) These should be listed at the beginning of a paper.
(b) Please take careful note of the notation to be used in describing biological wastewater treatment processes. Authors should consult "Recommended Notation for Use in the Description of Biological Wastewater Treatment Processes", *Water Research*, Volume 16, pp. 1501–1505 (1982).

9. *Introductions*

Introductions to papers should be confined strictly to the subject under consideration.

10. *Return of Manuscript*

Authors of accepted papers requiring the return of manuscript or original material should make their request known as soon as possible. Otherwise, these will be discarded one month after publication.

NOTE: The above is to be used as a general guide for individual reports. Supplementary information regarding, for example, format and abbreviations will be forwarded immediately following the Conference.

ATTACHMENT IV

USANC REIMBURSEMENT REQUEST

Expenses incurred relating to preparation of interpretive analysis of the 12th Biennial International Water Pollution Research and Control Conference, Amsterdam, The Netherlands, September 17-21, 1984. The first column should show the total cost of developing the report including your services and expenses - the information is needed for cost sharing calculations. Show in the second column the actual reimbursement requested. Leave the third column blank.

ITEM	(1) AMOUNT	(2) REIMBURSEMENT REQUESTED	(3) REIMBURSEMENT APPROVED
Professional Services (collection/ assimilation/analysis of information, report preparation, etc.) _____days @ $_____per day*			
Conference Registration ($330)**			
Subsistence during Conference** (Hotel and meals) _____days @ $80 per day			
Travel Cost** Air: - Within U.S. - International*** Personal Auto - Within U.S. ___miles @ 20¢ per mile			
Miscellaneous (please itemize) - Limousine, cab fare - - (no rental cars, no secretarial)			

*Indicate days claimed and consulting rate per day (USANC will set a maximum).

**Attach Conference registration, hotel and air travel receipts.

***International Travel is considered to be from U.S. city of embarkation to Amsterdam and return to the U.S.; include amount in Column (1) only.

Send this voucher to:

Richard A. Conway
Research and Development
Union Carbide Corporation
P. O. Box 8361 (770-432)
South Charleston, WV 25303

____
Signature

____
Social Security

____
Date of Submission

FOR COORDINATING SUBCOMMITTEE USE ONLY:

Amount Paid__________Date__________

DEVELOPMENTS OUTSIDE OF FORMAL SESSIONS

Much of the beneficial exchange of technical information occurring at professional meetings takes place outside of the formal sessions. At international conferences, the opportunities for such effective information transfer are considerable. Recognizing this potential, participants in the development of this report were asked to submit comments obtained from such interactions with water pollution researchers from other nations. Comments of possible interest to U.S. water pollution researchers, not part of the formal conference program, are summarized in this section. These comments have been identified with an individual participant and do not necessarily reflect the views of USANC.

Coal Gasification Wastewater Treatment

Several observations and comments relating to this topic were presented in the main body of the report and are not repeated here relating to water pollution control at South Africa's SASOL II coal gasification plant near Secunda. SASOL is the acronym for the South African Coal, Oil and Gas Corporation. It represents the largest synfuels operation in the world and is presently meeting close to 20% of the petroleum demands of the country (Heaton).

SASOL I, located at Sasolburg and southwest of Johannesburg, has been converting coal to gaseous and liquid products since 1957. SASOL II was completed in 1980 at a cost of approximately $2.5 billion and is near Secunda, which is east of Johannesburg. SASOL III, a mirror image of SASOL II, began operation this year at the same site and was built at a cost of $3.5 billion.

Little detailed information is available, such as output, actual costs and government subsidies because of national security issues. However, the following information was made available on the scheduled tour (Wednesday, April 7, 1982) to SASOL II:

(1) Gasoline at service stations sells for 66¢/ℓ and SASOL technology is competitive at this price. When the plants were built, it was not and the management depended heavily on inflation and increases in world oil prices to justify construction. Their attitude toward our United States synfuels industry is that, "If we don't do it now, we'll never do it." However, South Africa is in a unique position in that they have no natural oil and few friendly nations with which to trade.

Memorandum: "Supplement to Guidelines for Preparation of Individual Reports," October 23, 1984

IAWPRC

UNITED STATES OF AMERICA NATIONAL COMMITTEE
FOR REPRESENTATION OF THE UNITED STATES TO THE
INTERNATIONAL ASSOCIATION ON WATER POLLUTION RESEARCH & CONTROL

CHAIRMAN:
DR. FRED G. POHLAND (AEEP)
SCHOOL OF CIVIL ENGINEERING
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ATLANTA, GEORGIA 30332
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208 NORTH ROMINE STREET
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SECRETARY-TREASURER:
MR. RICHARD A. CONWAY (ASCE)
RESEARCH & DEVELOPMENT DEPARTMENT
UNION CARBIDE CORPORATION
P. O. BOX 8361 (770-342)
SOUTH CHARLESTON, WEST VIRGINIA 25303
(304) 747-4016

October 23, 1984

TO: Participants assisting in development of USANC Report on Amsterdam Conference

FROM: F. G. Pohland Fred Pohland

SUBJECT: Supplement to Guidelines for Preparation of Individual Reports

Acceptable individual reports are due no later than 7 January 1985. To assist in developing your report and to aid in assembling the complete report by the editors, additional guidelines are included.

First and foremost, the report is to be an interpretive analysis of significant developments at the Conference. Preparation of simply a record of the Conference proceeding is of little value in this regard. Reviewers must critically evaluate and interpret all technical aspects of their Conference experiences to prepare a satisfactory report. If all that is done is to report on what will be or has been published by IAWPRC, we will have failed. Preparation of an acceptable report will, therefore, take considerable forethought and planning.

In addition to the report sections identified previously, another separate section is requested. A summary chapter is to be presented in the final report indicating, by technical-area groupings, some of the important conclusions reached in the papers and poster presentations. Each reviewer is, therefore, requested to submit a separate section entitled "Overview of Developments at Formal Sessions". This section is to be a series of 1- to 3-sentence paragraphs, grouped by technical area, which present the important conclusions resulting from the formal sessions. This section in reality is an abstract of the longer report developed for your assigned papers and highlights the most significant conclusions of the Conference. See Attachment A for further information on this section.

SPONSORING ORGANIZATIONS

ASSOCIATION OF ENVIRONMENTAL ENGINEERING PROFESSORS AMERICAN CHEMICAL SOCIETY
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS AMERICAN SOCIETY OF CIVIL ENGINEERS WATER POLLUTION CONTROL FEDERATION

12TH BIENNIAL INTERNATIONAL CONFERENCE, AMSTERDAM, NETHERLANDS, 17-20 SEPTEMBER 1984

Some additional guidelines include:

1. Manuscripts must be DOUBLE SPACED on only one side of the sheet.
2. Margins of at least 1.5 in. on all sides are required.
3. All data must be presented in metric units. If it was not presented in these units, convert it to metric units.
4. The country of all authors, presenters, and discussers must be identified. Include the country parenthetically after an individual's name, each time the individual's name is used, e.g., "Smith (Japan) indicated...". A list of countries of conference participants is included in Attachment B. Note that U.S.A. is the only country to be abbreviated.
5. Unless it is obvious from the author listing, indicate the name (and country) of the presenting author in the text of the review, e.g., "Smith (Japan) presented a model...".
6. Headings for reviews of presented papers and posters are similar, but are not identical. See Attachments C and D for the required formats.
7. Reviewers should submit a separate and complete report for all assigned presentations and a separate and complete report for all assigned posters. Section VI of each report (as described in the letter of 28 August, 1984) should be initiated on a separate sheet since this material is to be combined with that from others into a separate section.

P.S. ALL REVIEWERS ARE REQUESTED TO RETURN THE CASSETTE TAPES OF THEIR SESSIONS WITH THE SUBMISSION OF THE FINAL REPORT.

FGP/hb

ATTACHMENT A: OVERVIEW OF DEVELOPMENTS AT FORMAL SESSIONS

This section is to be initiated on a separate sheet and is to include all significant conclusions drawn from paper and poster presentations in abstract form. If numerous conclusions can be drawn from a single paper or poster, they should be included as separate, single-paragraph entries. To identify the formal source of the conclusive statement, each paragraph should end with a designation of the source, i.e., paper or poster. For example, each paragraph should end as follows: "...(Paper No. C1, Denmark)."; or "...(Poster Presentation No.P1, Netherlands).".

The format for this section is as follows:

OVERVIEW OF DEVELOPMENTS AT FORMAL SESSIONS

Technical Area - 1

Technical Area - 2

Technical Area - 3

Examples of summary paragraphs from the USANC report for the Cape Town Conference (1982) are presented below.

Analytical Techniques

Detailed procedures for the measurement of wastewater phenolic compounds in domestic wastewaters and sludges using capillary GC/MS/DS techniques were presented (Paper No. 30, U.S.A.)

The use of a thermally-modulated electron capture detector, i.e., two electron-capture detectors in series with a catalytic pyrolysis unit, in conjunction with two-dimensional gas chromatography, were presented as an emerging analytical procedure. The technique was shown to be useful in identifying haloacetylnitriles and trihalomethanes in drinking water (Paper No. 16, U.S.A.).

Fixed Film Biological Reactors

Effects of turbulence and other factors controlling transfer of oxygen to the bulk liquid of rotating biological contactors (RBC) were shown to become relatively less significant as the size of RBC units increases (Paper No. 27, U.S.A.). Most oxygen transfer occurs through the biofilm.

Sludge Treatment, Utilization, and Disposal

Clinker formation in multiple hearth furnaces was found to be associated with high temperatures and long residence times. Volatilization of cadmium from sludge incinerated in a multiple hearth furnace was reported to be increased at higher temperatures, but most of the cadmium was recovered in scrubber water (Paper No. 11, Canada).

The potential use of rheological measures to identify optimal sludge conditioning dosages was described (Paper No. 14, Canada).

Current South African regulations for land spreading of sludges are based on the philosophy that only a sludge with no *E. coli*, *Ascaris* ova or pathogenic viruses is one unlikely to cause disease (Poster Presentation S6, South Africa). Current research in South Africa is directed to developing data on safe levels of these agents, as well as for metals, for spreading or land use for various purposes. *Ascaris* ova were found to be resistant to inactivation by major sludge treatment methods (Poster Presentation S36).

Physical-Chemical Treatment

Chlorine reacted with three organic bases in different ways (Paper No. 35, U.S.A.). Current ability to anticipate reaction products is limited.

Slow sand filtration systems were shown to be effective means of controlling the cercariae (*Schistosoma mansoni*) of human schistomes (Paper No. 17, U.S.A.).

Ultrafiltration was successfully used to recover PVA from a textile wastewater following pretreatment using filtration or centrifugation to remove small fibers (Paper No. 45, South Africa).

Eutrophication

A Water Quality Index was used to indicate improvements in water quality in an urban reservoir resulting from the termination of nutrient flow from an influent wastewater treatment plant (Paper No. 60, Federal Republic of Germany).

A two-year study of an urban catchment was conducted to determine the means of import and export of nitrogen, phosphorus, COD, BOD, and heavy metals. Atmospheric deposition accounted for virtually all of the soluble nitrogen contained in storm water transport but accounted for less than half of the other materials in runoff. The use of the unmodified SWMM model produced excellent runoff hydrographs but failed to predict the transport of pollutants in storm water. This lack of correlation was attributed to the lack of appropriate atmospheric deposition rates in the model (Paper No. 62, South Africa).

Raw Water Quality

Studies conducted to determine causes of taste and odor in natural river waters must include comprehensive monitoring of inorganic and organic constituents as well as detailed evaluations of resident algal populations (Paper No. 13, France).

The concentration of nitrates in the Thames River increased from an average value of 4.2 mg N/ℓ in 1968 to 7.7 mg N/ℓ in 1979, and, based on model projections, it will be 9.8 to 15.5 mg N/ℓ by the year 2000. A new European Economic Community Directive establishes a maximum permissible nitrate concentration of 11.3 mg N/ℓ (Paper No. 46, United Kingdon).

ATTACHMENT B: COUNTRIES OF CONFERENCE PARTICIPANTS[*]

Australia
Austria
Belgium
Bophuthatswana
Brazil
Bulgaria
Canada
Colombia
Curacao
Cyprus
Czechoslovakia
Denmark
Egypt
Federal Republic of Germany
Finland
France

Greece
Hong Kong
Hungary
India
Oram
Ireland
Israel
Italy
Japan
Jordan
Kenya
Korea
Kuwait
Luxemburg
Malaysia
New Zealand
Nigeria

Norway
Philippines
Poland
Portugal
Saudi Arabia
South Africa
Spain
Sweden
Srilanka
Switzerland
Syria
Thailand
Turkey
Uganda
United Kingdom
U.S.A.
Yugoslavia
Zimbabwe

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[*] *Delegates List*, 12th Biennial International Conference on Water Pollution Control, 17-21 September 1984.

ATTACHMENT C: FORMAT FOR REVIEWS OF PAPER PRESENTATIONS*

I. SESSION

A. Day: Day of week, month, day of month, 1984
Hall:
Time: _:__ to _:__

B. Theme of Session:

II. REVIEWER

A. Name:

B. Position:
Affiliation:

III. DESCRIPTION OF SESSION PAPERS

A. Paper No. C_ : "Title," by A. Author, B. Author, C. Author and D. Author (County)

B. Paper No. C_ : "Title," by A. Smith (Country)

IV. CRITIQUE OF SESSION

V. SIGNIFICANCE AND VALUE TO AMERICAN WATER POLLUTION RESEARCH ACTIVITIES

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*An example of the text for this section was included as ATTACHMENT I with the letter of 28 August 1984.

ATTACHMENT D: FORMAT FOR REVIEWS OF POSTER PRESENTATIONS

I. SESSION

   A. Day: September 17-20, 1984
      Hall: RAI Conference Centre

   B. Theme of Poster Presentations:

II. REVIEWER

   A. Name:

   B. Position:
      Affiliation:

III. DESCRIPTION OF POSTER PRESENTATIONS

   A. Poster Presentation No. P_: "Title," by A. Author (Country)

IV. CRITIQUE OF SESSION

V. SIGNIFICANCE AND VALUE TO AMERICAN WATER POLLUTION RESEARCH ACTIVITIES

APPENDIX D

Assignments: Participants in USANC Report

ASSIGNMENTS

Participants in USANC Project

A. TECHNICAL PRESENTATIONS

Date	Time	Hall	Reviewer	Paper No.
Sept. 17	2:00- 5:25	1	DiGiano, F.A.	P-1 - P-5
		2	Gerba, C.P.	P-35 - P-39
		3	Keith, L.H.	P-69 - P-73
Sept. 18	9:00- 12:25	1	Randall, C.W.	P-6 - P-10
		2	O'Melia, C.R.	P-40 - P-44
		3	Bryant, C.W., Jr.	P-74 - P-78
Sept. 18	2:00- 5:25	1	Malina, J.F., Jr.	P-11 - P-15
		2	Bowen, P.T.	P-45 - P-49
		3	Hendricks, D.W.	P-79 - P-83
Sept. 19	9:00- 12:25	1	Rittman, B.E.	P-16 - P-20
		2	Carberry, J.B.	P-50 - P-54
		3	Weber, W.J., Jr.	P-84 - P-88
Sept. 19	2:00- 5:25	1	Alleman, J.E.	P-21 - P-25
		2	Eckenfelder, W.E. & Sobsey, M.D.	P-55 - P-59
		3	Schultz, J.R.	P-89 - P-93
Sept. 20	9:00- 12:25	1	Patterson, J.W.	P-26 - P-30
		2	Herricks, E.E.	P-60 - P-64
		3	Baumann, E.R.	P-94 - P-98
Sept. 20	2:00- 4:20	1	Grady, C.P.L.	P-31 - P-34
		2	Molof, A.H.	P-65 - P-68
		3	Khudenko, B.M.	P-99 -P-102

B. POSTER PRESENTATIONS

Reviewer	Poster Presentation
Malina, J.F., Jr.	P-8, P-15, P-29
Carberry, J.	P-7, P-11, P-14
Pruel, H.C.	P-4, P-10, P-20

B. POSTER PRESENTATIONS (continued)

Reviewer	Poster Presentation
Huang, C.P.	P-5, P-16, P-35, P-38, P-42, P-44, P-48, P-49, P-55, P-57
Gerba, C.P.	P-25
DiGiano, F.A.	P-3, P-12, P-17
Herricks, E.E.	P-18, P-39
Rittman, B.E.	P-33
Hendricks, D.W.	P-2, P-6, P-22
Bryant, C.W., Jr.	P-9, P-40
Bowen, P.T.	P-27, P-34, P-37

C. PRE- AND POST-CONFERENCE SEMINARS

Date	Seminar/ Location	Reviewer	Paper & Poster Nos.
Sept. 12-14	Freshwater Biological Monitoring/ Cardiff, United Kingdom	Herricks, E.E.	Paper Nos. 1-21
Sept. 20-22	Water Virology/ Bilthoven, The Netherlands	Sobsey, M.D.	Paper Nos. C-53-C-57; Paper Nos. 1-5, 7-14; Poster Nos. V-1, V-4, V-5, V-6, V-8, V-9, V-11, V-13, V-14 V-15, V-16, V-17
Sept. 24-25	Advanced Technologies for Removal and Disposal of Micropollutants/ Antwerp, Belgium	King, P.H. & Sierka, R.A.	Paper Nos. 1-10

D. REPORT DEVELOPMENT

Conway, R.A.
Ford, D.L.
Keinath, T.M.
Speece, R.E.

E. Report Editors

Pohland, F.G.
Saunders, F.M.